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Analyzing the Multi-national Cooperative Acquisition Aspect of the Joint Strike Fighter (JSF) Program

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December 2009

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13. ABSTRACT

The JSF program is a cooperative acquisition program involving the U.S. and eight partner nations to design, develop, and produce a next-generation fighter. Although the program is led by the U.S., the participant nations cooperate to produce an affordable yet advanced aircraft by exchanging technology and information, as well as investing in the program and receiving commensurate returns. The allied nations will then possess an advanced aircraft that they could not afford to develop on their own. Therefore, in order to successfully execute this complicated aircraft program, the U.S. has implemented an unprecedented acquisition strategy that it envisages as a model for cooperation in future international programs. The best value approach, international partners' early involvement, and leveled program participation are salient features of this strategy. However, even with innovative approaches and strong management efforts, the program's unit cost has increased 50 percent since 2001, with schedule delays of 2.5 years. In order to understand this complexity, this report analyzes the JSF program's international cooperative acquisition strategy. Specifically, this report investigates (a) whether the JSF acquisition strategy is a useful model for prospective acquisitions, and (b) the nature of Turkey's participation.

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ANALYZING THE MULTI-NATIONAL COOPERATIVE ACQUISITION ASPECT OF THE JOINT STRIKE FIGHTER (JSF) PROGRAM

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Submitted in partial fulfillment of the requirements for the degree of

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LIST OF ACRONYMS AND ABBREVIATIONS

AESA	Multi-Mission Active Electronically Scanned Array
AL	Autonomic Logistics
APUC	Average Procurement Cost
ASTOVL	Advanced Short Takeoff and Vertical Landing
BEA	British Aerospace Electronic
BUR	Bottom-Up Review
CDP	Concept Demonstration Phase
CDR	Critical Design Reviews
CRS	Congress Research Service
CTOL	Conventional Takeoff and Landing
CV	Carrier Variant
DARPA	Defense Advanced Research Projects Agency
DAS	Distributed Aperture System
EMD	Engineering and Manufacturing Development Phase
EOTS	Electro-Optical Targeting System
FAR	Federal Acquisition Regulation
FY	Fiscal Year
GAO	Government Accountability Office
GE	General Electric
HMD	Helmet Mounted Displays
HMDS	Helmet Mounted Display System

HUD	Head-Up-Display
IOT&E	Initial Operation Test and Evaluation
JAST	Joint Advanced Strike Technology
JSF	Joint Strike Fighter
KPPs	Key Performance Parameters
LOL	Letter of Intent
LRIP	Low-Rate Initial Production
MFDS	Multi-Function Display System
MOU	Memorandum of Understanding
MRF	Multirole Fighter
NATO	North Atlantic Treaty Organization
P&W	Pratt & Whitney
PAUC	Program Acquisition Unit Cost
PDR	Preliminary Design Review
PDRR	Program Definition and Risk Reduction
PSFD	Production, Sustainment and Follow on Development
R&D	Research and Development
SAR	Selected Acquisition Reports
STOVL	Short Takeoff Vertical Landing
SDD	System Development and Demonstration
TEI	TUSAS Engine Industry
U.S. DoD	United States Department of Defense
U.K.	United Kingdom

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I. INTRODUCTION

A. BACKGROUND

The Joint Strike Fighter (JSF) is a cooperative program between the United States Department of Defense (U.S. DoD) and eight U.S. allies for developing and producing the next generation fighter aircraft to replace their aging inventories.[1] The program began in November 1996 with a five-year competition between Lockheed Martin and Boeing to determine the most capable and affordable preliminary aircraft design. Lockheed Martin won the competition, and the program entered system development and demonstration in October 2001.[2] The program's purpose is to develop and field an affordable, highly common family of stealthy, next-generation strike fighter aircraft for the U.S. Navy, Air Force, Marine Corps, and eight U.S. allies.

The JSF is critical to the ability of the U.S. DoD and its allies to replace their aging fighter fleets. The goal is to develop an affordable warfighter that is superior in performance to competitors like Euro Typhoon or other fifth generation warfighters and to garner a larger market for the U.S. defense contractors. The JSF program is the U.S. DoD's most expensive aircraft program to date. According to official program estimates, the total expected investment just for U.S. DoD is now more than 1 trillion dollars—more than 300 billion dollars to acquire 2,456 aircraft and 760 billion dollars in life cycle operation and support costs.[3]

The international partners of this program are the United Kingdom, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway. These nations are

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[1] U.S. General Accounting Office, Joint Strike Fighter Acquisition: Cooperative Program Needs Greater Oversight to Ensure Goals Are Met,GAO-03-775, (Washington DC:GAO, July 21, 2003), 1, http://www.gao.gov/new.items/d03775.pdf.

[2] U.S. Government Accounting Office, DoD Plans to Enter Production before Testing Demonstrates Acceptable Performance, GAO-06-356, (Washington DC: GAO, March 2006), 3, http://www.gao.gov/new.items/d06356.pdf.

[3] United States Government Accountability Office, *Joint Strike Fighter: Accelerating Procurement before Completing Development Increases the Government's Financial Risk*, GAO-09-303, (Washington DC: GAO, March 12, 2009), 1, http://www.gao.gov/new.items/d09303.pdf.

contributing funds for system demonstration and development, so they have signed the agreements to procure a minimum of 730 aircraft. Israel and Singapore are security cooperation participants, and several other nations have reportedly expressed interest in acquiring aircraft.

In addition to obtaining cutting edge technology aircraft, the various participants in the JSF program have different purposes and expectations related to their involvement. The U.S. expects to reduce its share of program costs, to acquire access to foreign industrial capabilities, and to improve interoperability with allied militaries. Allied governments expect to benefit from defined influence over aircraft requirements, to improve relationships with U.S. aerospace companies, to acquire access to JSF program data/technology, and to benefit from the program through industrial participation.

The pillars of the program are affordability, lethality, survivability and supportability. U.S. DoD decided to implement unprecedented acquisition approaches to develop an affordable but highly advanced aircraft. Also, unexampled approaches are envisaged as a model for prospective international cooperative acquisitions. The dominant features of these approaches are best value acquisition, international partners' earlier involvement to the program, and leveled program participation.

This study discusses the reasons for international cooperation to the JSF program, the unprecedented acquisition approaches, the current status of the program, and whether the JSF program's unexampled acquisition strategy can be a model for prospective international cooperative acquisitions.

B. PURPOSE

The purpose of this research is to analyze the JSF program's international cooperative acquisition strategy. Thus, this research primarily focuses on the international cooperative aspects of the JSF program's acquisition. The research seeks to clarify the motives behind cooperation between the U.S. and its partner nations, the benefits and drawbacks of the JSF acquisition strategy, and the performance of Turkey in the JSF program. The fundamental research question that this study will seek to answer concerns

the adaptability of the JSF program's international cooperative acquisition strategy to other prospective acquisitions. This research thus analyzes unique aspects of the program, such as the best value approach, leveled participation, and allied nations' earlier involvement to the program. Additionally, research considers the program's current situation and the reasons for cost increases and schedule delays.

C. RESEARCH QUESTIONS

Can the JSF program's acquisition strategy serve as a model for prospective international cooperative acquisitions?

What are the political/military objectives of the JSF program?

What are the economic objectives of the JSF program?

What are the technological objectives of the JSF program?

What are the industrial objectives of the JSF program?

What are the strengths and weaknesses of the JSF program's acquisition strategy?

What are the U.S. DoD's expectations of the JSF program?

What are the participant nations' expectations of the JSF program?

How does Turkey benefit from the program?

How well does Turkey perform on the JSF subcontracts?

D. SCOPE

The scope of this research is limited to the international cooperative acquisition aspects of the program. The study does not analyze or discuss program aspects which relate only to the U.S. and do not affect the entire program. The study also forgoes country by country analysis of the participant nations' industrial participation in the program.

E. METHODOLOGY

The methodology of this research is limited to literature review of sources related to the JSF program. The data concerning the program are derived from the Government Accountability Office (GAO) reports, the U.S. DoD's Selected Acquisition Reports

(SAR), the Congress Research Service (CRS) reports, the JSF program office's official Web site, and the Turkish National Defense Undersecretariat for Defence Industries.

The data received from the Turkish National Defense Undersecretariat for Defence Industries are obtained by the "Turkish Freedom of Information Act" and are unofficially translated by the author of this report.

F. ORGANIZATION OF STUDY

Chapter I is an introduction to the topic, "Analyzing the Multi-national Cooperative Acquisition Aspect of the Joint Strike Fighter Program." It provides a basic overview of this MBA project, including the purpose of the thesis, the research questions to be answered in this project, and the scope and research method to be utilized.

Chapter II, JSF Program History and Current Status, is a literature review. First, it gives detailed information about the program's origin, history, pillars, definition of the requirement, and key performance parameters. Second, the chapter provides detailed information about the program's acquisition details such as timelines, milestones, contractors, procurement quantities, and GAO critiques about the program's acquisition strategy. Third, it outlines budget details. Lastly, the chapter presents the allied nations' participation in and expectations of the program.

Chapter III is titled Analysis of the JSF Program's International Cooperative Acquisition Strategy. This chapter presents an analysis of the motivations behind international armaments cooperation, the JSF program's core objectives, the best value acquisition approach, leveled participation, and affordability.

Chapter IV is titled Turkey and the JSF Program. This chapter presents an analysis of Turkey's motives to participate in the program, its expectations and reactions to cost increases, and Turkish companies' industrial participation in the program.

Chapter V, Conclusions and Recommendations, provides a summary of the findings and makes recommendations based on those findings.

II. JOINT STRIKE FIGHTER PROGRAM HISTORY AND CURRENT STATUS

A. GENERAL

Before analyzing the multinational cooperative acquisition aspect of the JSF program, this chapter reviews the relevant literature. The chapter begins with a summary of the history of the program since 1993. In order to understand the current status of the program, there follows a description of the program, characteristics of the acquisition strategy, and current budget details. Finally, the chapter presents a comprehensive review of the allied nations' participation in the program as well as the relationship between the allied nations, the U.S., and the contractors.

The quantitative data related to the cost of the aircraft and the budget details of the program are derived from the GAO reports and the U.S. DoD Selected Acquisition Reports.

B. HISTORY OF THE JSF PROGRAM

In 1993, Secretary of Defense Les Aspin initiated a comprehensive review of the United States' defense strategy, force structure, modernization, infrastructure, and foundations. He felt that a department-wide review needed to be conducted "from the bottom up" because of the dramatic changes that had occurred in the world as a result of the end of the Cold War and the dissolution of the Soviet Union.[4] (Secretary of Defense Les Aspin's review is cited as 1993-Bottom-Up Review [BUR].) The purpose of the review was to define a strategy, force structure, and modernization plans for defense planning in the post-Cold War era. The BUR found that a number of combat aircraft that were the core of its aviation structure and key to the U.S. success in Operation Desert Storm were aging and required replacement.[5] As a result of the aircraft replacement, the

[4] U.S. Department of Defense, Report of Bottom-up-Review, (Washington, DC: DoD, October 1993), iii, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA359953&Location=U2&doc=GetTRDoc.pdf.

[5] Ibid, 35–38.

BUR produced two important tactical aviation results. The first was to cancel the A/F-X and Multirole Fighter (MRF), terminating production of the F-16 after FY 1994 and the F/A-18C/D after FY 1997, and proceeding with the F-22 and the F/A-18E/F, albeit at reduced quantities. The second was to launch the Joint Advanced Strike Technology (JAST) program in order to replace various services' aging aircraft with cutting edge technology aircraft at less cost.[6]

The purpose of the JAST was to develop an interoperable next generation aircraft as explained in the BUR. The BUR says:

> We will launch a JAST program that focuses on developing common components for future engines, avionics, ground support, training, munitions, and advanced mission planning. The technologies pursued under this program could be used with any future combat aircraft the nation decides to build. These common technologies account for the bulk of the cost incurred in acquiring and operating aircraft. Different airframes, […] are a lesser part of overall aircraft cost. Thus, we are aiming for a combat aircraft that, in terms of cost, is 80 percent "joint," although there may be different airframe silhouettes. We believe this will significantly reduce development and production cost for the next generation of Navy and Air Force aircraft, even if we elect to proceed with different airframes.[7]

In January 1994, the JAST program office was established to define and develop aircraft, weapon, and sensor technology that would support the future development of tactical aircraft. The JAST program initiated conceptual design studies with Boeing, Lockheed, McDonnell Douglas, and Pratt & Whitney. The objective of these studies was to define a technology maturation program, but was not focused on flight demonstration of a specific aircraft concept. The program subsequently moved from a broad, all-encompassing program to one that would develop a common family of aircraft to replace several aging U.S. and U.K. aircraft.[8]

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[6] Eric V. Larson, David T. Orletsky, and Kristin J. Leuschner, The Bottom-Up Review: Redefining Post–Cold War Strategy and Forces, (Santa Monica, CA: RAND, 2001), 57, http://www.rand.org/pubs/monograph_reports/MR1387/MR1387.ch3.pdf.

[7] U.S. DoD, Report of Bottom-up-Review, 38.

[8] Global Security, *Joint Advanced Strike Technology (JAST)*, http://www.globalsecurity.org/military/systems/aircraft/jast.htm.

In a short time after initiation, some observers criticized the JAST program for being a technology-development program rather than a focused effort to develop and procure new aircraft. In 1995, in response to congressional direction, the JAST merged with an advanced short takeoff and vertical landing (ASTOVL) aircraft development program led by Defense Advanced Research Projects Agency (DARPA).The new program included U.S. Marine Corps and British Navy participation. The name of the program was then changed to JSF to focus on joint development and production of a next-generation fighter/attack plane.[9] One important reason for the merge was the Clinton Administration's conclusion that future budgets could not sustain new aircraft development programs for both USAF and the Navy; thus, their projects were merged into a single program.[10]

The JSF program started in 1994 and proceeded in four phases. The first phase was the Concept Demonstration Phase (CDP), and occurred between 1994 and 1996. During that phase, Boeing, Lockheed Martin, and McDonnell Douglas (the latter teamed with Northrop Grumman and British Aerospace) worked on the prospective stealth aircraft. The companies competed to design new aircraft which would shape the future of U.S. tactical aviation and the U.S. defense industrial base. At the conclusion of this phase, the companies proposed three different aircraft designs.[11]

The second phase, Program Definition and Risk Reduction (PDRR), occurred between 1996 and 2001. On November 16, 1996, two companies, Boeing and Lockheed Martin, were chosen to compete for PDRR phase, in which each contractor would build and flight-test two aircraft to demonstrate their concepts for three JSF variants.[12] The JSF

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[9] Christopher Bolkcom, Joint Strike Fighter (JSF) Program: Background, Status, and Issues, CRS Report RL30563, (Washington DC: CRS, July 18, 2002), 2, http://assets.opencrs.com/rpts/RL30563_20020718.pdf.

[10] John A. Tirpak, "Strike Fighter", Air Force Magazine, Vol. 79, No. 10, (October 1996): 22–28, http://www.airforce-magazine.com/MagazineArchive/Pages/1996/October%201996/1096strike.aspx.

[11] Bolkcom, JSF Program: Background, Status, 2002, 2.

[12] Christopher Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program: Background, Status, and Issues, (Washington DC: CRS, February 17, 2009), 3, http://assets.opencrs.com/rpts/RL30563_20090217.pdf.

PDRR phase costs 2.2 billion dollars.[13] Pratt & Whitney provided propulsion hardware and engineering support for both Boeing and Lockheed Martin's JSF PDRR efforts. In addition to the United States, the United Kingdom, Denmark, Norway, the Netherlands, Canada, Italy, Singapore, Turkey, and Israel participated in this phase.

In August 2001, the PDRR phase concluded and the companies' demonstrators were evaluated by the U.S. DoD. On October 26, 2001, the DoD announced the Lockheed Martin team the winner of the competition.[14] Therefore, the Engineering and Manufacturing Development Phase (EMD) began, and Lockheed Martin and the government representatives signed a contract. While EMD is the official name for this phase, it is generally called the System Development and Demonstration (SDD) phase. The United States, the United Kingdom, Denmark, Norway, the Netherlands, Canada, Italy, and Turkey participated in the SDD phase.

The last phase is called the Production, Sustainment and Follow on Development (PSFD) phase. The participant nations signed contracts to participate in the program in 2006 and 2007. Its purpose is to cooperatively develop, produce, test, train, and operate the JSF aircraft that will enhance the interoperability, survivability, and affordability of the participant nations' forces future forces.[15] This phase will continue until the conclusion of full production, which is 2034. All SDD phase participant nations have participated in the last phase by committing to purchase these aircraft.

C. DESCRIPTION OF THE JSF PROGRAM

The purpose of the JSF program (also known as F-35 Lighting II Program) is to develop and manufacture cutting edge tactical aircraft variants for the U.S. Air Force,

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[13] Fighter Planes, Lockheed-Martin X-35 Joint Strike Fighter (JSF) / F-35 Lightning II, http://www.fighter-planes.com/info/jsf.htm.

[14] Global Security, *Joint Strike Fighter (JSF)*,, http://www.globalsecurity.org/military/library/budget/fy2001/dot-e/airforce/01jsf.html.

[15] United States Department of Defense, Department of Defense and Canada Sign Next Stage Joint Strike Fighter Agreement, December 11, 2006, http://www.defenselink.mil/releases/release.aspx?releaseid=10279.

Marine Corps, and Navy, as well as eight allied nations and various nations outside of the participating group. . The JSF is the U.S. DoD's largest acquisition program in terms of cost and number of aircraft to be produced and the longest in terms of procurement duration.[16] Current U.S. DoD plans call for production of 2,456 aircraft in three versions for the U.S. services and 722 aircraft for cooperative participant nations until 2034.

1. The Program's Overall Mission Need

The JSF is a joint program between the United States and Australia, Canada, Denmark, Italy, the Netherlands, Norway, the United Kingdom, and Turkey. These nations have a cooperative agreement to develop and field an affordable next generation aircraft. The JSF Program is led by the U.S. and is the U.S. DoD's focal point for defining affordable next generation strike aircraft weapon systems for the U.S. Navy, Air Force, Marines, and eight allied nations.[17]

The purpose of the JSF program is to develop and deploy a family of technically superior, lethal, survivable, and supportable but affordable cutting edge and stealth aircraft that perform a wide range of missions in a variety of theaters.[18]

The JSF is producing aircraft to fulfill the requirement of the U. S. Navy's first day of war, survivable strike fighter aircraft, the U.S. Air Force's multirole aircraft (primary-air-to-ground), the U.S. Marine Corps and the U.K.'s Short Takeoff/Vertical Landing (STOVL) aircraft, and other nations' Conventional Takeoff and Landing (CTOL) aircraft.[19] The overall design developed by Lockheed with partners Northrop Grumman and BAE Systems resembles a scaled-down F-22, but each F-35 variant is

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16 Christopher Bolkcom and Anthony Murch, F-35 Joint Strike Fighter (JSF) Program: Background, Status, and Issues, CRS Report RL30563, (Washington DC: CRS, August 29, 2008), 1, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA486544&Location=U2&doc=GetTRDoc.pdf.

17 F-35 Joint Strike Fighter Program Office, The JSF Program, http://www.jsf.mil/program.

18 U.S. Government Accounting Office. Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisition Strategy, GAO-05-271, (Washington DC: GAO, March 2005), 4, http://www.gao.gov/new.items/d05271.pdf.

19 F-35 Joint Strike Fighter Program Office, The JSF Program, http://www.jsf.mil/program/.

tailored to the specific needs of its operators.[20] The F-35A is developed for the U.S. Air Force, the F-35C for the U.S. Navy, and the F-35B for the U.S. Marines and the United Kingdom.[21] The three types of aircraft are designed to have maximum commonality in airframe, engine, and avionics components to reduce development, production, and operation and support costs. The F-35 types, requesting services/nations, and planned using purposes can be seen in Table 1.

Service	F-35 Type	Planned Use
U.S. Air Force	F-35A- (CTOL)	Replacement for the F-16 and A-10; complement the F/A-22
U.S. Marine Corps	F-35B- (STOVL)	Replacement for the AV-8B and F/A-18 A/C/D
U.S. Navy	F-35B- (STOVL), F-35C- (CV)	Complement the F/A-18 E/F
United Kingdom	F-35B- (STOVL),	Harrier GR7, Sea Harrier FA2
Australia	F-35A- (CTOL)	Replacement for the F-111, F/A-18
Canada	F-35A- (CTOL)	Replacement for the F/A-18
Denmark	F-35A- (CTOL)	Replacement for the F-16
Italy	F-35A- (CTOL), F-35B- (STOVL),	Replacement for the AMX, Harrier, AV-8B and Tornado
Norway	F-35A- (CTOL)	Replacement for the F-16
Netherlands	F-35A- (CTOL)	Replacement for the F-16
Turkey	F-35A- (CTOL)	Replacement for the F-16

Table 1. Military Services' Planned Use for the Joint Strike Fighter. *Source*: GAO Report, GAO-06-356, 5.

2. Pillars of the JSF Program

[20] Aircraft Museum, Description of F-35, http://www.aerospaceweb.org/aircraft/fighter/f35/.

[21] Bolkcom and Murch, F-35 Joint Strike Fighter (JSF) Program, 3.

The JSF program has four pillars. The program seeks to produce lethal, survivable, and supportable but affordable aircraft. The F-35 Joint Strike Fighter Program Office's Web page gives details of each of these pillars. The F-35s will attain the following.[22]

a. Affordability

The primary focus of the program is affordability, decreasing the development cost, production cost, and ownership cost of the variant F-35 aircraft. The Web page of the JSF program strongly emphasizes the program's vision as "delivering and sustaining the most advanced, affordable strike fighter aircraft to protect future generations worldwide."[23]

The contractors are trying to achieve the affordability goal by developing and producing a high level of common parts and systems across the three versions of the aircraft.

b. Lethality

Every F-35 variant will be highly effective in both air-to-ground precision strikes in all weather and air-to-air combat engagements. The F-35 will be extremely lethal. It will have excellent aerodynamic performance and advanced integrated avionics. Its next generation stealth, superb situational awareness and reduced vulnerability will make the F-35 hard to find, hard to hit, and hard to kill.

c. Survivability

As a stealthy (radar-evading), high-performance, supersonic strike fighter, the F-35 successfully integrates the technologies that will make every mission more survivable.

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[22] F-35 Joint Strike Fighter Program Office, F-35 Background, http://www.jsf.mil/f35/f35_background.htm.

[23] F-35 Joint Strike Fighter Program Office, F-35 Leadership, http://www.jsf.mil/leadership/.

d. Supportability

The F-35 will set new standards for both reliability and maintainability, enabling lower support costs and easier upgrades compared to legacy aircraft.

3. Definition of the Requirement

The F-35 is one of the first fifth generation aircraft in the world, combining advanced stealth, sensor fusion, fighter agility, network-centric capability, and dramatically reduced support costs.[24] With its host of next-generation technologies and unprecedented capabilities, the F-35 will be far and away the world's most advanced multi-role fighter.[25] All JSF models will be single-seat, single engine aircraft with supersonic dash capability. Also, the F-35 is designed to be self-sufficient or part of a multisystem and multiservice operation, and to rapidly transition between air-to-surface and air-to-air missions while still airborne.[26]

Contrary to some misconceptions that the JSF would be one aircraft used by several services for different missions, the program focused on the development and production of three variants with common components and a common design.[27] These are known as F-35A, F-35B, F-35C. The details are:

- **F-35A- Conventional Takeoff and Landing (CTOL):** The F-35A uses standard runways for takeoffs and landings. It is a multirole, supersonic stealth fighter that has extraordinary acceleration and 9-g maneuverability with F-16-like agility.[28] The F-35A is designed for the U.S. Air Force and its cooperative allies; it is the primary export version of the Lightning II.

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24 The Aerospace Web page provides a useful definition of fifth generation fighters: The technologies that best epitomize fifth generation fighters are advanced integrated avionics systems that provide the pilot with a complete picture of the battlespace and the use of low observable "stealth" techniques. The F-22 and F-35 are the only fifth generation fighters developed to date.

25 Aviation Spectator, F-35 *Lightning II Joint Strike* Fighter: Aircraft profile, http://www.aviationspectator.com/resources/aircraft-profiles/f-35-lightning-ii-joint-strike-fighter-aircraft-profile.

26 U.S. Government Accounting Office. Opportunity to Reduce Risks, GAO-05-271, 4–5.

27 Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program, 2009, 3.

28 Lockheed Martin, F-35 Lightning II, The Future is Flying E-Brochure, http://www.lockheedmartin.com/data/assets/aeronautics/products/f35/A07-20536AF-35Broc.pdf.

- **F-35B- Short Takeoff/Vertical Landing (STOVL):** The F-35B is the first aircraft in history to combine stealth with short takeoff/vertical landing capability and supersonic speed. This distinction gives the F-35B the unique ability to operate from small ships, roads, and austere bases. The F-35B deploys near front-line combat zones, dramatically shrinking the distance from base to target, increasing sortie rates and decreasing the need for logistics support.[29]

- **F-35C- Carrier Variant (CV):** The U.S. Navy's first stealth aircraft operates from the service's large carriers via catapult launch and arrested recovery. Larger wings and control surfaces and the addition of wingtip ailerons allow the F-35C pilot to control the airplane with precision during carrier approaches. The aircraft incorporates larger landing gear and a stronger internal structure to withstand the forces of carrier launches and recoveries. Ruggedized exterior materials mean low maintenance requirements for preserving the aircraft's Very Low Observable radar signature, even in harsh shipboard conditions.[30] Pictures and short descriptions of the three versions of the F-35s can be seen in Figure 1.

[29] Lockheed Martin, *F-35B STOVL Variant*, http://www.lockheedmartin.com/products/f35/f-35-variants/f-35b-stovl-variant.html.

[30] Lockheed Martin, *F-35C CV Variant*, http://www.lockheedmartin.com/products/f35/f-35-variants/f-35c-cv-variant.html.

Conventional Take Off & Landing (CTOL)
Span (ft) 35
Length (ft) 50.5
Wing Area (ft2) 460
Internal Fuel (lb) 18,498

Short Take Off/Vertical Landing (STOVL)
Span (ft) 35
Length (ft) 50.5
Wing Area (ft2) 460
Internal Fuel (lb) 13,326

Carrier Variant (CV)
Span (ft) 43
Length (ft) 50.8
Wing Area (ft2) 620
Internal Fuel (lb) 19,624

Figure 1. Variants of the F-35. *Source:* www.jsf.mil.

4. General Technological Characteristics of the F-35s

Development of the F-35 family, which will be used by the U.S.'s three services and eight allies for different combat missions, requires cutting edge technology. To achieve its mission, JSF will incorporate low observable technologies, defensive avionics, advanced onboard and offboard sensor fusion, internal and external weapons, and advanced prognostic maintenance capability. According to the U.S. DoD, these

technologies represent a quantum leap over legacy tactical aircraft capabilities.[31] The general technological characteristics of the aircraft, taken from the official F-35 Program Office's Web page, are depicted below.[32]

Autonomic Logistics (AL): As logistics support accounts for two-thirds of an aircraft's life cycle cost, the F-35 will achieve unprecedented levels of reliability and maintainability, combined with a highly responsive support and training system linked with the latest in information technology. The aircraft will be ready to fight anytime and anyplace. AL is a seamless, embedded solution that integrates current performance, operational parameters, current configuration, scheduled upgrades and maintenance, component history, predictive diagnostics (prognostics) and health management, and service support for the F-35.

Commonality: Commonality is the key to affordability—on the assembly line; in shared-wing platforms; in common systems that enhance maintenance, field support, and service interoperability; and in almost 100 percent commonality of the avionics suite. Component commonality across all three variants reduces unique spares requirements and the logistics footprint. In addition to reduced flyaway costs, the F-35 is designed to affordably integrate new technology during its entire life cycle. According to a Congressional Research Report, the contractors have designed these three distinct variants of a multi-role fighter with a 70 percent to 90 percent common airframe to reduce production and maintenance costs.[33]

Interoperability: The F-35 will have the most robust communications suite of any fighter aircraft built to date. The F-35 will be the first fighter to possess a satellite communications capability that integrates beyond line of sight communications

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[31] U.S. Government Accounting Office, Management of the Technology Transfer Process, GAO-06-364, (Washington DC: GAO, March 2006), 3, http://www.gao.gov/new.items/d06364.pdf.

[32] F-35 Joint Strike Fighter Program Office, F-35 Technology, http://www.jsf.mil/f35/f35_technology.htm.

[33] According to the Lockheed Martin's Web page, "all F-35 versions are built on the same assembly line, share the same engine and are up to 80 percent common in their structures and systems." http://www.lockheedmartin.com/products/f35/f-35-variants/.

throughout the spectrum of missions it is tasked to perform. The F-35 will also contain the most modern tactical datalinks, which will provide the sharing of data among its flight members as well as other airborne, surface, and ground-based platforms required to perform assigned missions. The commitment of JSF partner nations to common communications capabilities and Web-enabled logistics support will enable a new level of coalition interoperability. These capabilities allow the F-35 to lead the defense community in the migration to the net-centric warfighting force of the future.

Low Observability: An integrated airframe design, advanced materials, and an axisymmetric nozzle maximize the F-35's stealth features.

Sophisticated Cockpit: The F-35 provides its pilot with unsurpassed situational awareness, positive target identification, and precision strike under any weather condition. Mission systems integration and outstanding over-the-nose visibility features are designed to dramatically enhance pilot performance.

Robust Structure: The F-35 features a strengthened continuous tailhook-to-nose-gear structure and catapult-compatible nose gear launch system for catapult and arresting loads.

Weapons Integration: The F-35 will employ a variety of U.S. and allied weapons. From JDAMs to Sidewinders and the UK Storm Shadow, the F-35 has been designed to internally or externally carry a large array of weapons.

Helmet Mounted Display System: Vision Systems International, LLC (VSI) is developing the most advanced and capable Helmet Mounted Display System (HMDS) for the F-35. Utilizing extensive design experience gained on successful production of Helmet Mounted Displays (HMD), the F-35 HMDS will replace the traditional Head-Up-Display (HUD) while offering true sensor fusion.

Distributed Aperture System: In a joint effort with Lockheed Martin Missiles and Fire Control, Northrop Grumman Electronic Systems will provide key electronic sensors for the F-35, including spearheading the work on the Electro-Optical Distributed Aperture System (DAS). This system will provide pilots with a unique protective sphere

around the aircraft for enhanced situational awareness, missile warning, aircraft warning, day/night pilot vision, and fire control capability.

Diverterless Inlet: The F-35's diverterless inlet lightens the overall weight of the aircraft. Traditional aircraft inlets were comprised of many moving parts and were much heavier than newer diverterless inlets. The diverterless inlet also eliminates all moving parts.

Electro-Optical Targeting System: Lockheed Martin Missiles and Fire Control and Northrop Grumman Electronic Systems are jointly providing key electronic sensors for the F-35 to include the Electro-Optical Targeting System (EOTS). The internally mounted EOTS will provide extended range detection and precision targeting against ground targets, plus long range detection of air-to-air threats.

Integrated Communications, Navigation and Identification Avionics: Northrop Grumman Space Technology's integrated avionics satisfy the requirements for greatly increased functionalities within extreme space and weight limitations via modular hardware that could be dynamically programmed to reconfigure for multiple functions. This "smart"-box approach delivers increased performance, quicker deployment, higher availability, enhanced scalability, and lower life cycle costs.

Multi-Function Display System: Rockwell Collins's 8"x20" Multi-Function Display System (MFDS) will be the panoramic projection display for the F-35. MFDS employs leading edge technology in projection engine architecture, video, compression, illumination module controls, and processing memory – all of which will make the MFDS the most advanced tactical display to date. One-gigabyte-per-second data interfaces will enable the MFDS to display six full motion images simultaneously. The adaptable layout will be easily reconfigurable for different missions or mission segments. Projection display technology will provide a high-luminance, high-contrast, and high-resolution picture with no viewing angle effect.

Multi-Mission Active Electronically Scanned Array (AESA) Radar: Northrop Grumman Electronic Systems is developing the AESA Radar for the F-35. This advanced

multi-function radar has gone through extensive flight demonstrations during the Concept Demonstration Phase. The radar will enable the F-35 JSF pilot to effectively engage air and ground targets at long range, while also providing outstanding situational awareness for enhanced survivability.

Propulsion: Two separate, interchangeable F-35 engines are under development: the Pratt & Whitney's F135 and the General Electric (GE) Rolls-Royce Fighter Engine Team's F136. Although the Pratt & Whitney's (P&W) F135 engine was selected as the basis for the various engine options of the JSF, in 1995 the U.S. Congress indicated a need for an "Alternate Engine" as a backup plan. The GE Rolls-Royce F136, inspired from the F-22 Raptor's engine F-120 that was in competition with the P&W's F119, was selected as the alternate engine for F-35s and is under development in collaboration with GE Rolls-Royce.[34] The Pratt & Whitney (F135) and the GE Rolls-Royce (F136) Fighter Engine Team engines are physically and functionally interchangeable across all F-35 aircraft and their autonomic logistics systems. Both engines bring key benefits to the JSF aircraft: cooperative development in which common propulsion system components are used to minimize development costs, a wide range of options to meet individual customer requirements, and sharing of propulsion support equipment to simplify maintenance of either engine.[35]

4. Key Performance Parameters of the Program

The F-35A has six key performance parameters (KPPs) that address total ownership costs; these KPPs are also applicable to the F-35B and F-35C. The joint KPPs are: interoperability, radio frequency signature, combat radius, sortie generation rate, logistics footprint, and mission reliability. Short take-off distance and vertical lift bring back KPPs are unique to the F-35B and maximum approach speed KPPs are unique to the F-35C. The details of KPPs are listed in Table 2.

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[34] Greg Goebel, *The Lockheed Martin F-35 Joint Strike Fighter (JSF),* http://www.vectorsite.net/avf35.html.

[35] Lockheed Martin, F-35 Lightning II, Delivering on the Promise, 2008, 6, http://www.lockheedmartin.com/farnborough/docs/F-35-Brochure.pdf.

	KPP	STOVL	CTOL	CV
JOINT	*Radio Frequency Signature*	Very Low Observable		
	Combat Radius	450 nm USMC Profile	590 nm USAF Profile	600 nm USN Profile
	Sortie Generation	4 Surg / 3 Sust	3 Surg / 2 Sust	3 Surg / 2 Sust
	Logistics Footprint	< 8 C -17 equivalent loads (20 PAA)	< 8 C -17 equivalent loads (24 PAA)	< 46,000 cu ft 243 ST
	Mission Reliability	95%	93%	95%
	Interoperability	Meet 100% of critical, top-level Information Exchange Requirements Secure Voice and Data		
USMC	*STOVL Mission Performance* *Short Take-Off Distance*	550'	N/A	N/A
	STOVL Mission Performance *Vertical Lift Bring Back*	2 x 1K JDAM, 2 x AIM -120 With Reserve Fuel	N/A	N/A
USN	*Maximum Approach Speed*	N/A	N/A	145 knots

Notes: JSF Joint Program Office: October 11, 2007. PAA = Primary Aircraft Authorized, ST = Short Tons, Vertical Lift Bring Back = amount of weapons/fuel that can be safely landed with.

Table 2. JSF Key Performance Parameters. *Source:* Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program, 3.

D. THE JSF PROGRAM ACQUISITION DETAILS

The JSF is a joint, multinational acquisition program for the Air Force, Navy, Marine Corps, and eight international partners. It is also the largest and most expensive weapons system currently in development in terms of cost and amount of production and program longevity. The program's goals are to develop and field an affordable, highly common family of stealthy, next-generation strike fighter aircraft for the U.S. Navy, the Air Force, the Marine Corps, and the U.S. allies.[36]

1. Program Timeline and Milestones

The JSF program proceeded in four phases; the years 1994-1996 are called the Concept Development Phase (CDP), the first phase of the program.

[36] U.S. Government Accounting Office, Joint Strike Fighter: Progress Made and Challenges Remain, GAO-07-360, (Washington DC: GAO, March 2007), 1, http://www.gao.gov/new.items/d07360.pdf.

The second phase was the Program Definition and Risk Reduction (PDRR). This phase began in November 1996 with a 5-year competition between Lockheed Martin and Boeing to determine the most capable and affordable preliminary aircraft design. Lockheed Martin won the competition, and this phase concluded in October 2001. The third phase was the Engineering and Manufacturing Development Phase (EMD), which began in October 2001.[37] This phase planned to conclude in 126 months, April 2012,[38]but is rescheduled to conclude in 2014. The milestones of the JSF program can be seen in Figure 2.

Figure 2. Milestones of the JSF Program. *Source:* GAO Report, GAO-09-326SP, 93.

The program is currently in the eighth year of the SDD phase. During the SDD phase, the Lockheed led team is required to build 14 flying development aircraft (five F-35As, four F-35Bs, five F-35Cs) and eight non-flying full-sized articles.[39] Flight testing is being carried out at Edwards Air Force Base, California, and Naval Air Station, Patuxent River, Maryland.[40]

Until 2003, system integration efforts and a preliminary design review revealed significant airframe weight problems that affected the aircraft's ability to meet key performance requirements. Weight reduction efforts were ultimately successful but

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[37] EMD is more official name for this phase; mostly it is called System Development and Demonstration Phase (SDD).

[38] F-35 Joint Strike Fighter Program Office, JSF EMD Solicitation Documents, Call for Improvement: Section F- Deliveries and Performance, http://www.jsf.mil/downloads/down_documentation.htm.

[39] Bill Sweetman, Ultimate Fighter:Lockheed Martin F-35 Joint Strike Fighter, (St Paul, MN:Zenith Press, 2004), 98.

[40] SPG Media Naval Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), USA*, http://www.naval-technology.com/projects/jsf/.

increased the cost of the program and caused schedule delays.[41] In April 2003, JSF completed a successful preliminary design review (PDR).[42] But in March 2004, the DoD rebaselined the JSF program, the program schedule extended by 18 months, and the development cost increased by 7.5 billion dollars.[43]

The critical design reviews (CDR) for the F-35A and F-35B were completed in February 2006, and for the F-35C in June 2007. The first flight of the CTOL F-35A took place on December 15, 2006, and the first flight of F-35C is planned in December 2009. The F-35B flew in conventional mode in June 2008, but the full capacity flight was rescheduled to September 2009. The initial operational capability is scheduled for March 2012 for the U.S. Marine Corps with F-35B, March 2013 for the U.S. Air Force with F-35A, and March 2015 for the U.S. Navy with F-35C.[44]

Low-rate initial production (LRIP) for the F-35A and F-35B was approved in April 2007 with an order for two F-35A aircraft. The U.S. DoD procured two aircraft in 2007 and 12 aircraft in 2008. Currently, the program is under low-rate production and aircraft testing. So far, two percent of the test has been concluded, and 28 aircraft will cumulatively be procured by the U.S. DoD by the end of 2009.[45] By the completion of operational testing in October 2014, the U.S. DoD will have purchased a total of 383 aircraft. The completion of operational testing and full rate production outset are planned for October 2014.

The initial operation test and evaluation (IOT&E) phase is a subset of the SDD phase, allowing contributing nations to participate in this phase. Participating nations are

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41 U.S. Government Accounting Office. Joint Strike Fighter: Impact of Recent Decisions on Program Risks, GAO-08-569T, (Washington DC: GAO, March 11, 2008), 4, http://www.gao.gov/new.items/d08569t.pdf.

42 SPG Media Naval Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), USA,* http://www.naval-technology.com/projects/jsf/.

43 U.S. Government Accounting Office, Impact of Recent Decisions, GAO-08-569T, 4.

44 U.S. Government Accounting Office, Joint Strike Fighter: Strong Risk Assessment Essential as Program Enters Most Challenging Phase, GAO-09-711T, (Washington DC: GAO, May 20, 2009), 18, http://www.gao.gov/new.items/d09711t.pdf.

45 Ibid, 15.

to sign up during the IOT&E phase MOU in 2009.[46] In October 2008, Italy announced that it intended to withdraw from participation in the IOT&E.[47]

Details of the program schedule, original estimate, 2004 replan, and current estimate are given in Table 3.

	Original Estimate	2004 Replan	Current Estimate
Critical Design Review			
Conventional Takeoff and Landing	Apr-04	Oct-05	Feb-06
Carrier Variant	Jul-05	Jan-07	Jun-07
Short Takeoff and Vertical Landing	Oct-04	May-06	Feb-06
First Flight			
Conventional Takeoff and Landing	Nov-05	Jul-06	Dec-06
Carrier Variant	Jan-07	Aug-08	Dec-09
Short Takeoff and Vertical Landing	Apr-06	May-07	Jun-08*
Initial Operational Capability			
Marine Corps	Apr-10	Mar-12	Mar-12
Air Force	Jun-11	Mar-13	Mar-13
Navy	Apr-12	Mar-13	Mar-15
1st Production Aircraft Delivered	Jun-08	Jun-09	Jan-10
Operational Testing Completed	Mar-12	Oct-13	Oct-14
Full Rate Production	Apr-12	Oct-13	Oct-14

Source: GAO analysis of DOD data.

Note:

* Aircraft flown in conventional mode. The first test to demonstrated full short takeoff and vertical landing capabilities is scheduled for September 2009.

Table 3. F-35 JSF Schedule. *Source:* GAO Report, GAO-09-711T, 18.

The fourth phase is called the Production, Sustainment and Follow-on Development (PSFD) phase. During this phase, production, testing, and fielding of the aircraft is taking place concurrently. The phase began in 2007 after the participant nations signed the Memorandum of Understanding (MOU). This phase is scheduled to continue until 2034. Australia, Canada, the Netherlands, and the United Kingdom signed the MOUs for the F-35 Production, Sustainment and Follow-on Development (PSFD) phase at the end of 2006. Norway, Turkey, Denmark, and Italy signed the MOUs at the beginning of 2007.[48]

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[46] Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program, 2009, 9.

[47] SPG Media, Naval Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), USA,* http://www.naval-technology.com/projects/jsf/.

[48] SPG Media, Air Force Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), International,* http://www.airforce-technology.com/projects/jsf/.

The engine programs have followed a different timeline. In October 2001, Pratt & Whitney was awarded the contract to develop the engine F135. In August 2005, the GE Rolls-Royce Team was awarded a contract to develop an alternate engine program, the engine F136. In 2010 and 2011, Pratt & Whitney and the GE Rolls-Royce Team will be awarded noncompetitive contracts. But after 2012, one of the engines will be selected annually under a competitive approach. In 2007, Pratt & Whitney was awarded the first of the annual production contracts.[49] The first flight of the F-35 powered by the GE Rolls-Royce F136 engine is scheduled for 2010, with first production engine deliveries in 2012. A critical design review was completed in February 2008.[50]

2. Program Dollar Value

a. Dollar Value of the JSF Air System Engineering and Manufacturing Development Program

On October 26, 2001, the U.S. DoD declared that it was awarding Lockheed Martin Corp., Lockheed Martin Aeronautics Co., Fort Worth, Texas, an 18,981,928,201 dollars cost-plus-award-fee contract for the Joint Strike Fighter Air System EMD program. The principal objectives of this phase are to develop an affordable family of strike aircraft and an autonomic logistics support and training system. According to the U.S. DoD's contract winner declaration at the DoD's Web page, 66 percent of the work would be performed in Fort Worth, Texas, 20 percent of work would be performed in El Segundo, California, and 14 percent of work would be performed in Warton/Samlesbury, United Kingdom, and was expected to be completed in April 2012. This contract was competitively procured through a limited competition; the other competitor was Boeing.[51]

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[49] U.S. Government Accounting Office, Impact of Recent Decisions, GAO-08-569T, 4.

[50] SPG Media, Naval Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), USA*, http://www.naval-technology.com/projects/jsf/.

[51] U.S. Department of Defense, October 26, 2001Contract Awards List, http://www.defenselink.mil/contracts/contract.aspx?contractid=2131.

Lockheed Martin's cost-plus-award-fee contract calls for a potential award fee of almost 2.83 billion dollars, or 15 percent of the total contract value. The exact amount of the fee is determined by the program office, based on mostly subjective criteria related to Lockheed Martin's ability to achieve development and unit cost control, program management, and technical development goals and milestones.[52]

According to the JSF Program Office, so far the current estimated cost for this phase is 46.8 billion dollars. In addition to this 46.8 billion dollars, 9.8 billion dollars is required to conclude the development in October 2014.[53]

a. Dollar Value of the JSF Engine Development Program

On October 26, 2001, the U.S. DoD also awarded Pratt & Whitney the Joint Strike Fighter Air System Engineering and Manufacturing Development Program. Pratt & Whitney, Military Engines, East Hartford, Connecticut, was being awarded a 4,803,460,088 dollars cost-plus-award-fee contract for the design, development, fabrication and test of the F135 propulsion system and common hardware as necessary to complete ground testing and demonstrate conformance with specification requirements; the fabrication of propulsion systems for Joint Strike Fighter air system flight testing; and the fabrication of common hardware for the General Electric aircraft engine F136 Propulsion System Flight Test Program.

The Web page of the U.S. DoD states that the JSF engine development program contract provided for system test and evaluation; propulsion system program management; F135 integration management; engine interchangeability and common hardware integration management for the F133 propulsion system; repair development; support system design; development and implementation; a training and training equipment program; shipping system and module container design and delivery; flight test spare and repair parts; flight test support for F136 Propulsion System Program Phases

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[52] U.S. General Accounting Office, JSFn: Cooperative Program Needs Greater Oversight to Ensure Goals Are Met,GAO-03-775, 24.

[53] U.S. Government Accounting Office, Strong Risk Assessment Essential, GAO-09-711T, 3.

III and IV; and technical, administrative, and financial data. Also, the Web page stated that 72 percent of the work would be performed in East Hartford, Connecticut; 16 percent in Middletown, Connecticut; one percent in West Palm Beach, Florida; and 11 percent in the United Kingdom (subcontractor—Rolls Royce) and was expected to be completed in April 2012.[54]

On August 19, 2005, the GE Rolls-Royce Fighter Engine team was awarded a 2,466,258,499 dollars cost-plus-award-fee and cost-plus-fixed-fee contract for the Joint Strike Fighter F136 System Development and Demonstration (SDD) Program. The U.S. DoD's contract award declaration stated that this contract provided for continued efforts required to meet SDD Program's milestones and mitigate technical, schedule, and cost risk, resulting in the delivery of six flight test engines to Lockheed Martin. Fifteen percent of the contract work will be done in The United Kingdom, and 85 percent will be done in the United States. The work should be completed in September 2013.[55]

According to a GAO report published in 2008, the current estimated life cycle cost for the JSF engine program under a sole-source scenario (just Pratt & Whitney's cost) is 54.9 billion dollars. Furthermore, a GAO report published in 2007 states that to ensure competition by continuing to implement the JSF alternate engine program, an additional investment of 3.6 billion dollars to 4.5 billion dollars may be required.[56] The details of Pratt & Whitney's cost details from the 2008 GAO report are featured in Table 4.

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[54] U.S. Department of Defense, October 26, 2001 Contract Awards List, http://www.defenselink.mil/contracts/contract.aspx?contractid=2131.

[55] U.S. Department of Defense, August 22, 2005 Contract Awards List, http://www.defenselink.mil/contracts/contract.aspx?contractid=3077.

[56] U.S. Government Accounting Office, Defense Acquisitions: Analysis of Costs for the Joint Strike Fighter Engine Program, GAO-07-656T, (Washington DC: GAO, March 22, 2007), 1, http://www.gao.gov/new.items/d07656t.pdf.

Cost element	Cost
System development and demonstration costs	$0.7
Total engine unit recurring flyaway costs	$19.5
Production support costs (including initial spares, training, manpower, and depot standup)	$3.1
Sustainment costs of fielded aircraft	$31.6
Total	**$54.9**

Source: JSF program office data; GAO analysis.

Note: Based on 2,443 installed engines and spares.

Table 4. Cost to Complete Pratt & Whitney F135 Engine Program. *Source:* GAO Report, GAO-08-569T, 11.

3. Estimated Procurement Quantities

In October 2001, the U.S. DoD planned to procure 2866 aircraft for its services. But in 2004, during the rebaseline work, the procurement amount was decreased to 2455 aircraft (13 aircraft for development plus 2443 aircraft procurement until 2034).

In 2006 and 2007, during the PSFD participation process, the participant nations also committed to buy aircraft. Australia committed to buy 100 aircraft, Canada 80, Denmark 48, Italy 131, the Netherlands 85, Norway 48, Turkey 100, and the United Kingdom 138. In total, the participant nations will buy 730 aircraft before 2034. The estimated year by year JSF aircraft procurement quantities of the participants are depicted in Table 5.

Participant	CY 07	CY 08	CY 09	CY 10	CY 11	CY 12	CY 13	CY 14	CY 15	CY 16	CY 17	CY 18
Australia	0	0	0	0	4	8	15	15	15	15	15	13
Canada	0	0	0	0	0	0	0	16	16	16	16	16
Denmark	0	0	0	0	0	0	0	8	8	8	8	8
Italy	0	0	0	0	0	6	6	14	14	14	14	14
Netherlands	0	0	1	1	0	6	10	10	12	12	12	12
Norway	0	0	0	0	0	0	0	8	12	12	12	4
Turkey	0	0	0	0	0	10	10	10	12	12	10	10
U.K.	0	0	2	1	0	6	1	8	11	12	13	12
U.S.	2	12	16	30	43	82	90	116	130	130	130	130
Total	2	12	19	32	47	118	132	205	230	231	230	219

Continued

Participant	CY 19	CY 20	CY 21	CY 22	CY 23	CY 24	CY 25	CY 26	CY 27	CY28-CY-35	Total
Australia	0	0	0	0	0	0	0	0	0	0	100
Canada	0	0	0	0	0	0	0	0	0	0	80
Denmark	8	0	0	0	0	0	0	0	0	0	48
Italy	12	12	12	12	1	0	0	0	0	0	131
Netherlands	9	0	0	0	0	0	0	0	0	0	85
Norway	0	0	0	0	0	0	0	0	0	0	48
Turkey	10	10	6	0	0	0	0	0	0	0	100
U.K.	12	7	2	1	1	12	13	13	11	0	138
U.S.	130	130	130	130	130	127	80	80	80	515	2443
Total	181	159	150	143	132	139	93	93	91	515	3173

Table 5. Participants' Estimated JSF Aircraft Procurement Quantities (April 2007 Revision). *Source:* www.jsf.mil.

4. Prime Contractors

An international cooperative team, shaped in accordance with the requirements of the JSF program and led by Lockheed Martin, heads development, production, and support of the F-35s. Northrop Grumman Cooperation and British Aerospace Electronic

Systems are principal subcontractors on an F-35 industry team led by main contractor Lockheed Martin Aeronautics. The engine program's (F135) contractor is Pratt & Whitney, while the alternative engine program's (F136) contractor is General Electric (GE) and Rolls Royce Cooperation.

a. Lockheed Martin Aeronautics Company

Lockheed Martin Aeronautics Company is the prime contractor for the F-35 JSF program. Along with the government-operated JSF Program Office, the company bears ultimate responsibility for the aircraft and all of its systems. Lockheed Martin benefited from cooperation by Northrop Grumman Corporation and British Aerospace Electronic Systems, as well as many more subcontractors and suppliers across the United States and around the globe. Lockheed Martin is engaged in the design, oversight, and support of every major F-35 subsystem. The company is also responsible for producing the F-35's forward fuselage, wings, and edges, which will be mated to the center fuselage (Northrop Grumman) and the aft fuselage and tails (BAE SYSTEMS) in Fort Worth, Texas. [57]

b. Northrop Grumman Corporation

As a principal member of the Lockheed Martin team, Northrop Grumman plays a key role in the development and demonstration of the family of F-35s.[58] Northrop Grumman provides and develops low-observable/stealth technology. In addition to providing support in logistics, sustainment, modeling, simulation, and mission planning, Northrop Grumman provides:

- Design and integration of the center fuselage,
- Mission systems software components,
- Ground and flight test support,

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[57] F-35 Joint Strike Fighter Program Office, Lockheed Martin's Role in the F-35 Joint Strike Fighter Program, http://www.jsf.mil/downloads/down_mediakits.htm.

[58] F-35 Joint Strike Fighter Program, Office. Northrop Grumman's Role on the F-35 Joint Strike Fighter, http://www.jsf.mil/downloads/down_mediakits.htm.

- Fire control radar,
- Electro-optical distributed aperture system,
- Integrated communications, navigation, and identification avionics suite.[59]

The company is building an international F-35 supplier team focused on providing "best value" to its customers. To date, the company has awarded some of its most significant subcontracts to firms based in partner countries, including an agreement to produce at least 400 center fuselages in Turkey starting in the low rate initial production phase of the program.[60]

c. British Aerospace Electronic (BAE) Systems (United Kingdom)

BAE Systems is a prime contractor from the United Kingdom. According to the JSF Program Office's Web page, this company brings a rich heritage of capabilities to the JSF program, including short takeoff and vertical landing experience, advanced lean manufacturing, flight testing, and air system sustainment. In both the United Kingdom and the United States, British Aerospace Electronic Systems designs and develops:

- Aft fuselage and empennage (tails and fins),
- Electronic warfare systems,
- Vehicle management computer,
- Navigation and identification modules,
- Pilot side-stick controller and throttle.

BAE Systems is also responsible for the fuel, crew escape, life-support, Prognostics and Health Management systems, and the U.K.'s Future Carrier F-35 integration support.[61]

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[59] Lockheed Martin, F-35 Lightning II, The Future is Flying, http://www.lockheedmartin.com/data/assets/aeronautics/products/f35/A07-20536AF-35Broc.pdf.

[60] Northrop Grumman Cooperation, F-35A Lightning II (CTOL), http://www.as.northropgrumman.com/products/f35jsf_ctol/index.html.

[61] F-35 Joint Strike Fighter Program Office, BEA Fact List, http://www.jsf.mil/downloads/down_mediakits.htm.

d. Pratt & Whitney

On October 26, 2001, the U.S. DoD awarded a ten year, 4.8 billion dollar (U.S.) contract for the SDD phase to Pratt & Whitney. Under the SDD contract, Pratt & Whitney is developing the F135 propulsion system through flight clearance, flight test, and qualification for LRIP. The first LRIP deliveries are scheduled for 2009.[62]

The JSF acquisition strategy requires the development of two propulsion systems. The Pratt & Whitney's engine competes, in production, with one developed by the team of General Electric and Rolls Royce. The P&W and GE/RR engines will be physically and functionally interchangeable in both the aircraft and support systems. All JSF aircraft variants will be able to use either engine. The competition will start in fiscal year 2011 and will continue through the life of the program to reduce risks.[63] According to Lockheed Martin, the interchangeable engines will provide:

- Cooperative development in which common propulsion systems components are used to minimize development cost,
- Wide range of options to meet individual customer requirements,
- Sharing of propulsion support equipment to simplify maintenance of either engine.[64]

A GAO report published in 2004 states that Rolls Royce (located in the United Kingdom) and Hamilton Sundstrand are major subcontractors to Pratt & Whitney for this effort. In addition to the F135 engine, Pratt & Whitney is also responsible for developing certain common propulsion system components that will interface with both engine cores.[65]

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[62] Pratt & Whitney, F-135Background-System Development and Demonstration, http://www.f135engine.com/media-center/backgrounder.shtml.

[63] U.S. Department of Defense, October 26, 2001 JSF Contact Award Immediate Release, http://www.defenselink.mil/releases/release.aspx?releaseid=3129.

[64] Lockheed Martin, F-35 Lightning II, The Future is Flying, http://www.lockheedmartin.com/data/assets/aeronautics/products/f35/A07-20536AF-35Broc.pdf.

[65] U.S. General Accounting Office. Joint Strike Fighter Acquisition: Observations on the Supplier Base, GAO-04-554, (Washington DC:GAO, May 3, 2004), 4, http://www.gao.gov/new.items/d04554.pdf.

e. GE Rolls-Royce Fighter Engine Team (The Fighter Engine Team)

The Fighter Engine Team was created in July 2002 by General Electric and Rolls-Royce, and formed for the development, deployment, and support of the F136 engine for the JSF program.[66] The engine F136 is one of the two primary propulsion systems for F-35 aircraft. The GE Rolls-Royce Fighter Engine Team includes: GE Transportation - Aircraft Engines in Cincinnati, Ohio, USA; and Rolls-Royce plc in Bristol, England, and Indianapolis, Indiana, USA. GE is developing 60 percent of the program, and Rolls Royce is developing 40 percent.[67]

In August 2005, the DoD awarded a 2.47 billion dollar contract for alternate engine system development and demonstration to the GE Rolls Royce Team.[68] The team plans to deliver the first F136 engine in 2011.[69]

5. Procurement Method Used

The JSF's procurement method was contracting by negotiation in keeping with Federal Acquisition Regulations (FAR). The government conducted discussions in accordance with FAR 15.306 and requested proposal revisions in accordance with FAR 15.307.

F-35 solicitation proceeded as a limited competition between two major aircraft producers, Lockheed Martin and Boeing. After Lockheed Martin's selection for Engineering and Manufacturing Development, Boeing was eliminated and ceased work on the JSF program. A 'winner takes all' strategy was implemented.

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66 U.S. Government Accounting Office, Impact of Recent Decisions,GAO-08-569T, 4.

67 General Electric Aviation, Model 136 Joint Strike Fighter Engine, http://www.geae.com/engines/military/f136/index.html.

68 U.S. Department of Defense, August 22, 2005Contract Awards List, http://www.defenselink.mil/contracts/contract.aspx?contractid=3077.

69 GE Aviation, *Joint Strike Fighter Engine*, http://www.geae.com/engines/military/f136/index.html.

The government intended to conduct a negotiated competition and desired to select one offer based on the proposal providing the "best value" to the government, all factors considered.[70]

6. Type of Contract and Contract Incentives

The U.S. DoD used a COST-PLUS-AWARD-FEE contract for the SDD phase. The total available award fee is 15 percent of the contract. Award fee categories are affordability, management, and technical and developmental cost control.

According to FAR Part 16.305, a cost-plus-award-fee contract is a cost-reimbursement contract that provides for a fee consisting of:

- A base amount (which may be zero) fixed at inception of the contract,
- An award amount, based upon a judgmental evaluation by the government,
- Sufficient to provide motivation for excellence in contract performance.

According to the definition of cost-plus-award-fee in FAR Part 16.405-2, a cost-plus-award-fee provides for a fee consisting of a base amount fixed at the inception of the contract and an award amount that the contractor may earn in whole or in part during performance. That is sufficient to provide motivation for excellence in such areas as quality, timeliness, technical ingenuity, and cost-effective management. The amount of the award fee to be paid is determined by the government's judgmental evaluation of the contractor's performance in terms of the criteria stated in the contract.

According to FAR 16.405-2, the cost-plus-award-fee contract is suitable for use when:

- The work to be performed is such that it is neither feasible nor effective to devise predetermined objective incentive targets applicable to cost, technical performance, or schedule;

[70] F-35 Joint Strike Fighter Program Office, Call for Improvement, JSF EMD Solicitation Documents, Section-M, Evaluation Factor for Award, (Washington D.C.:DoD, 2001), 1, http://www.jsf.mil/downloads/.

- The likelihood of meeting acquisition objectives will be enhanced by using a contract that effectively motivates the contractor toward exceptional performance and provides the government with the flexibility to evaluate both actual performance and the conditions under which it was achieved;
- Any additional administrative effort and cost required to monitor and evaluate performance are justified by the expected benefits.[71]

The U.S. DoD chose the cost-plus-award-fee contract type to motivate the contractors for excellence in such areas as quality, timeliness, technical ingenuity, and cost-effective management and bear the risk of an innovative contract. The award fee evaluation covers the Award Fee Categories set forth in Table 6:

Award Fee Category:	**Area of Emphasis:**
Affordability:	Reduction in development, production, and ownership cost, Affordability Assessment Process (Contract Award through CDR), Affordability Improvement Curve (CDR through Contract Completion)
Management:	Responsiveness, Schedule, Subcontract Management (includes small business utilization)
Technical:	Air System Development, Air System Software Development
Developmental Cost Control:	EVMS Implementation, Actual Contract Performance

Table 6. JSF Contract Award Fee Categories. *Source:* JSF EMD Solicitation Documents, www.jsf.mil.

[71] Federal Acquisition Regulation (FAR) Part-16, http://www.acquisition.gov/far/current/html/Subpart%2016_4.html#wp1078212.

7. GAO Critiques and Recommendations on the JSF Acquisition Strategy

Between 2005 and 2009, the GAO insistently recommended two major modifications on the JSF acquisition strategy. The first was to have an evolutionary and knowledge-based acquisition approach and the second was to switch the cost-plus-award-fee to a fixed-price contract.

a. Have an Evolutionary, Knowledge-based Acquisition Strategy

Since 2005, the GAO has released five reports (GAO-09-303, GAO-08-388, GAO-07-360, GAO-06-356, GAO-05-271) expressing concern about the substantial overlap of development, test, and production activities and recommended a more evolutionary and knowledge-based acquisition strategy with limited investment in production aircraft until each variant demonstrates required capabilities in flight testing.[72]

According to the GAO reports, the DoD Instruction 5000.2, Operation of the Defense Acquisition System, and best practices all call for programs to use an acquisition strategy that reflects an evolutionary, knowledge-based approach. This approach ensures that appropriate technology, design, and manufacturing knowledge are captured at key milestones before committing to increased investments. As seen in The Defense Acquisition Management Framework (Figure 3), the advancement to each step requires fulfillment of the current step or milestone.

[72] U.S. Government Accountability Office, *Joint Strike Fighter: Accelerating*, GAO-09-303, 1.

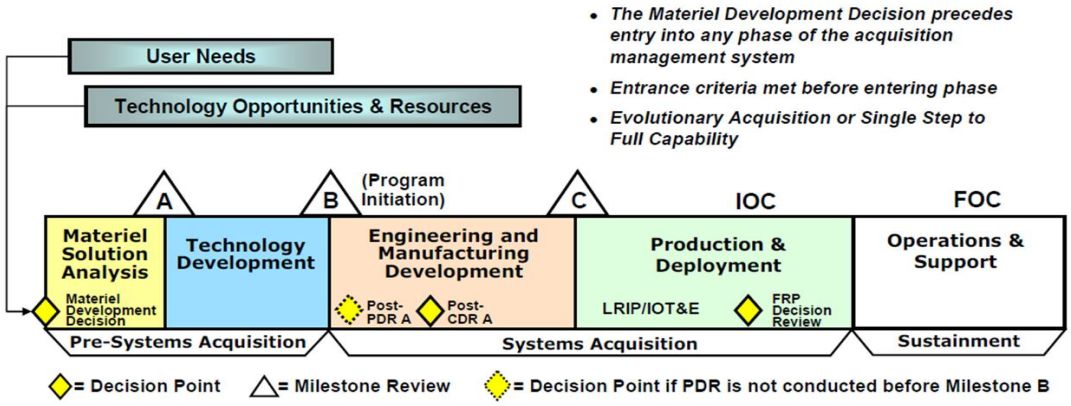

Figure 3. Defense Acquisition Management Framework. *Source:* DoD Instruction 5000.2: Operation of the Defense Acquisition System.

However, as seen in Figure 4, the JSF program has a concurrent acquisition approach in which the technology development phase overlaps with the initial system development and system development overlaps with low-rate initial production. Contrary to DoD Instruction 5000.2, the U.S. DoD has a current commitment to procure a large quantity before 2013 (273 aircraft, 11 percent of the total procurement), before system development and testing have been completed. This move significantly increases the risk of further delays and cost increases due to design changes and manufacturing inefficiencies.[73] Thus, the U.S. DoD bears the financial risk of concurrently developing and initially producing the JSF on a cost reimbursement basis with the prime contractor, an uncommon practice for such a large number of units, until the design and manufacturing processes are mature.[74]

[73] U.S. Government Accounting Office, DoD Plans to Enter Production, GAO-06-356, 1–2.

[74] U.S. Government Accounting Office, Opportunity to Reduce Risks, GAO-05-271, 14.

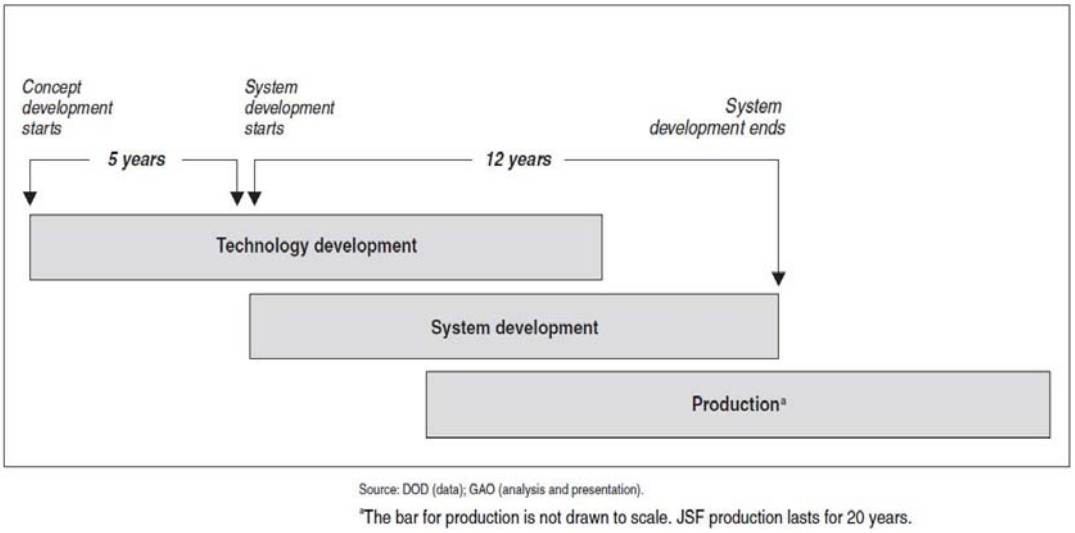

Figure 4. Joint Strike Fighter Program Acquisition Strategy. *Source:* GAO Report, GAO-06-356, 14.

b. Switch to Fixed-Price Contract

In 2001, the U.S. DoD preferred to have a cost-plus-award-fee contract for the SDD phase of the program. Currently, the U.S. DoD is acquiring a substantial number of aircraft on this contract. Because of cost reimbursement contracts, the buyer, in this case the DoD, assumes most of the risk. Thus, the buyer is liable to pay more than budgeted should labor, material, or other incurred costs be more than expected when the contract was signed.[75] For that reason, the GAO recommends that the DoD switch to a fixed-price contract. However, JSF officials plan to procure at least the first four low-rate production lots under cost reimbursement contracts and to transition to fixed-price instruments when appropriate, possibly between lots five and seven (fiscal years 2011 to 2013). The latest GAO report points out the issue as:

> Cost reimbursement contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. According to the Federal Acquisition Regulation, cost reimbursement contracts are suitable for use only when uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed price contract. Cost

[75] U.S. Government Accounting Office, *Accelerating Procurement*, GAO-09-303, 12–13.

> reimbursement contracts for weapon production are considered appropriate when the program lacks sufficient knowledge about system design, manufacturing processes, and testing results to establish firm prices and delivery dates. In contrast, a fixed-price contract provides for a pre-established price, places more of the risk and responsibility for costs on the contractor, and provides more incentive for efficient and economical performance.[76]

As seen in Figure 5, to date, the U.S. DoD has procured the first two low-rate production lots for a total of 14 aircraft and 3.6 billion dollars on cost reimbursement terms and plans to procure at least 44 aircraft by paying 10.1 billion dollars in the next two years.

	2007	2008	2009	2010	2011	2012	2013	2014
Cumulative procurement (billions of then-year dollars)	$0.9	$3.6	$6.9	$13.7	$20.6	$31.1	$41.9	$54.3
Cumulative aircraft procured	2	14	28	58	101	183	273	383
Contract type	Cost	Cost	Cost	Cost	Cost or fixed	Cost or fixed	Cost or fixed	Fixed
Percentage of flight test program completed	<1%	<1%	2%	9%	34%	62%	88%	100%
LIMITED KNOWLEDGE GAINED FROM FLIGHT TESTING →					*MORE KNOWLEDGE GAINED FROM FLIGHT TESTING*			

Source: GAO analysis of DOD data.

Figure 5. Overlap of Procurement Investment and Flight Testing. *Source:* GAO Report, GAO-O9-711T, 15.

E. THE JSF PROGRAM BUDGET DETAILS

1. Funding and Projected Cost

The JSF program is the U.S. DoD's costliest aircraft acquisition program.[77] The GAO currently estimates that the total cost of development and procurement of 2,456

[76] U.S. Government Accounting Office, *Accelerating Procurement*, GAO-09-303, 13.

[77] U.S. Government Accounting Office. Tactical Aircraft: DoD Needs a Joint and Integrated Investment Strategy, GAO-07-415. (Washington DC: GAO, April 2007), .48, http://www.gao.gov/new.items/d07415.pdf.

aircraft will run 300 billion dollars, and that the life cycle and support cost will be over 760 billion dollars; thus the JSF program will cost the U.S. DoD more than one trillion dollars.[78]

At the start of the JSF program in November 1996, the U.S. DoD planned to acquire 2,988 aircraft, expected first aircraft delivery in 2007, and expected initial operation in 2010. At the outset of the program in October 2001, the U.S. DoD was planning to purchase 2866 aircraft at a total acquisition cost of 233 billion dollars; the first delivery was to occur in 2008 while the initial operation would take place in 2010-2012.

At the end of 2003, the U.S. DoD reduced total aircraft numbers to 2,457. The estimated total acquisition cost increased to 244.80 billion dollars and the expected first delivery and the initial operation were delayed to 2009 and 2012–2013, respectively.[79]

According to the latest GAO report, the U.S. DoD is planning to buy 2,456 aircraft at an estimated total acquisition cost of 298.8 billion dollars. The current expected first operational aircraft delivery year is 2010, and the initial operational capability is to occur in 2012-2015.

Overall, the cost estimate to develop the JSF has increased from 34.40 billion dollars in 2001 to 44.40 billion dollars in 2007, about 29 percent. According to the JSF Program Office, the current estimated cost for this phase is 46.8 billion dollars. In addition to this 46.8 billion dollars, 9.8 billion dollars is required to conclude the development by October 2014.[80]

The program acquisition unit cost (PAUC) of the aircraft was estimated as 81 million dollars in 2001, 100 million dollars in 2003, and 122 million dollars now. PAUC has increased 50 percent since the beginning of the development phase.

Details of cost increases, schedule overruns, and the program's evolution are depicted in Table 7:

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[78] U.S. Government Accounting Office, *Accelerating Procurement*, GAO-09-303, 1.

[79] Allied nations signed agreements to procure minimum of 730 aircraft.

[80] U.S. Government Accounting Office, Strong Risk Assessment Essential, GAO-09-711T, 3.

	November 1996 (Program start)[81]	October 2001 (System development start)	December 2003 (2004 replan)	December 2006 Date	December 2007
Expected Quantities					
Development Quantities	10	14	14	15	13
U.S. Procurement Quantities	2978	2852	2443	2443	2443
Total Quantities	**2988**	**2866**	**2457**	**2458**	**2456**
Cost Estimates (then year dollars in Billions)					
Development*	$24.80	$34.40	$44.80	$44.50	$44.40
Procurement	Not available	$196.60	$199.80	$231.70	$254.00
Military Construction	Not available	$2.00	$0.20	$0.20	$0.50
Total Program Acquisition	**Not available**	**$233.00**	**$244.80**	**$276.40**	**$298.8**
Unit Cost Estimates (then year dollars in Millions)					
Program Acquisition	Not available	$81.00	$100.00	$112.00	$122.00
Average Procurement	Not available	$69.00	$82.00	$95.00	$104.00
Estimated Delivery Dates					
First Operational Aircraft Delivery	2007	2008	2009	2009	2010
Initial Operational Capability	2010	2010-2012	2012-2013	2012-2015	2012-2015

Table 7. Changes in JSF Program Purchase Cost, Quantities, and Delivery Estimates. *Source:* GAO Report, GAO-09-303, 5.

[81] U.S. Government Accounting Office, Progress Made and Challenges Remain, GAO-07-360, 5. (The original chart does not cover data for 1996; these data are derived from this GAO report**).**

2. The Evolution of the JSF Program Cost Estimates on the Selected Acquisition Reports

A review of the Selected Acquisition Reports demonstrates the extent of budget increases since 2001. The summaries of budget increase amounts and reasons as explained in the program Selected Acquisition Report's since 2001 are summarized below.

2001—Development costs increased 7,904.2 million dollars (+3.6 percent) from 218,554.1 million dollars to 226,458.3 million dollars, due primarily to delay of the SDD phase decision, extension of the SDD phase from a 90-month to 126-month effort employing a block approach, a refined cost estimating model with a more detailed work breakdown structure, and addition of two flight test aircraft to the program. As a result of the Defense Acquisition Executive (DAE) Milestone B approval, the program entered into the SDD phase in October 2001, and 196,600 million dollars of procurement for 2,866 production aircraft has been added to the SAR.[82]

2002—Program costs decreased by 26,721.9 million dollars (-11.8 percent) from 226,458.3 million dollars to 199,736.4 million dollars, due primarily to a decrease of 409 Navy aircraft (from 2,866 to 2,457 aircraft) (-25,434.9 million dollars).[83]

2003—Program costs increased 45,097.9 million dollars (+22.6 percent) from 199,736.4 million dollars to 244,834.3 million dollars, due primarily to revised contractor direct labor and overhead rates, the SDD phase schedule extension for additional design maturation, a delay in procurement start from FY 2006 to FY 2007 with revised annual quantity profiles, and learning curve impacts of revised SDD and production schedules on contractors.[84]

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[82] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2001 December Selected Acquisition Reports, (Washington DC: December 31,2001), 10–11, http://www.acq.osd.mil/ara/am/sar/2001-Dec-SARSUMTAB.pdf.

[83] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2002 December Selected Acquisition Reports, (Washington DC: December 31, 2002), 8, http://www.acq.osd.mil/ara/am/sar/SARST1202.pdf.

[84] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2003 December Selected Acquisition Reports, (Washington DC: December 31, 2003), 5, http://www.acq.osd.mil/ara/am/sar/2003-Dec-SARSumTable.pdf.

2004—Program costs increased 11,783.3 million dollars (+4.8 percent) from 244,834.3 million dollars to 256,617.6 million dollars, due primarily to increases for application of revised escalation indices, design maturation, refined definitions of support requirements, and a delay in initial procurement from FY 2007 to FY 2008 with a revised buy profile for all variants.[85]

2005—Program costs increased 19,841.3 million dollars (+7.7 percent) from 256,617.6 million dollars to 276,458.9 million dollars, due primarily to the increased cost of materials for the airframe, revised inflation impact assumptions and methodology, revised assumptions regarding the work share between the prime contractor and subcontractors, the application of revised escalation rates, impact of configuration update and methodology changes on support, a change in the subcontracting manufacture plan for the wing, and a realignment of funding to out years due to Congressional and Service FYDP reductions (+130.0 million dollars).[86]

2006—Program costs increased by 23,365.2 million dollars (+8.5 percent) from 276,458.9 million dollars to 299,824.1 million dollars, due primarily to a decrease in the annual procurement quantities, a stretch out of the production buy schedule from FY 2027 to FY 2034, and support increase due to aircraft configuration update, revised procurement profile, and methodology changes.[87]

2007—Program costs decreased by 981.3 million dollars (-0.3 percent) from 299,824.1 million dollars to 298,842.8 million dollars, due primarily to the application of

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[85] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2004 December Selected Acquisition Reports, (Washington DC: December 31, 2004), 8–9, http://www.acq.osd.mil/ara/am/sar/2004-DEC-SST.pdf.

[86] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2005 December Selected Acquisition Reports, (Washington DC: December 31, 2005), 9, http://www.acq.osd.mil/ara/am/sar/2005-DEC-SARSUMTAB.pdf.

[87] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2006 December Selected Acquisition Reports, (Washington DC: December 31,2 006), 7, http://www.acq.osd.mil/ara/am/sar/2006-DEC-SST.pdf.

revised escalation indices, lower material estimates because of prime contractor's material agreements, and incorporation of revised prime/subcontractor labor rates.[88]

Summary of the JSF program's current estimates of cost, quantity changes, and average unit cost changes are depicted in Table 8.

Month-Year	Current Estimate ($ in Millions)		Quantity	Average Unit Cost ($ in Millions)	Quarterly Changes $	
	Base Year	Then Year			Base Year	Then Year
Dec 2001		226,458.3	2886	78.47		+3.6
Dec 2002	161,543.9	199,736.4	2,457	81.29	1.4	-2.8
Dec 2003	191,632.9	244,834.3	2,457	99.65	20.3	19.1
Dec 2004	192,519.0	256,617.6	2,458	104.40	20.8	24.8
Dec 2005	201,729.4	276,458.9	2,458	112.47	26.6	34.5
Dec 2006	209,401.60	299,824.10	2,458	121.98	30.2	44.4
Dec 2007	210,014.50	298,842.80	2,456	121.68	30.6	44.0
Sep 2008[89]	210,014.50	298,842.80	2,456	121.68	30.6	44.0

Table 8. F-35 JSF Selected Acquisition Reports Summary- Base Year 2002

Average unit cost increased drastically between December 2002 and December 2006. The cost increase can be seen in Figure 6.

[88] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2007 December Selected Acquisition Reports, (Washington DC: December 31, 2007), 6, http://www.acq.osd.mil/ara/am/sar/2007-DEC-SARSUMTAB.pdf.

[89] U.S. Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), 2008 December Selected Acquisition Reports, September 30, 2008, http://www.acq.osd.mil/ara/am/sar/.

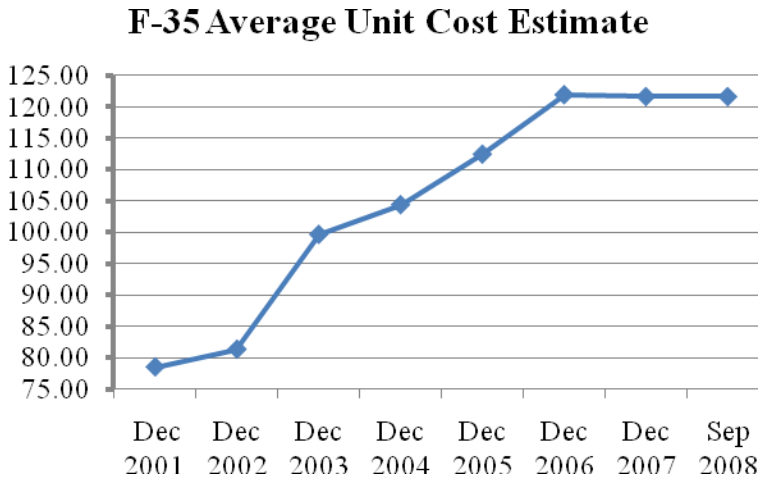

Figure 6. F-35 Average Unit Cost Estimate

F. ALLIED NATIONS' PARTICIPATION AND EXPECTATIONS

1. Purpose and Cooperative Framework

The F-35 JSF program is unquestionably one of the most unique and interesting programs in defense acquisition history in many aspects. Interesting and unique features include international participation, its antecedents and history, the project organization, and the responses by the many national and corporate participants. It is also interesting because of its potential effects on defense industries worldwide.[90] Jon A. Schriber, former JSF International Programs Director, explains the uniqueness of the program:

> It is unprecedented to have international involvement in a major U.S fighter development acquisition program not only this early in the development effort, but also during a critical competitive phase of the program. While other U.S. aircraft programs, such as the F-16 Program, have successfully involved international partners, it has been at a much later phase. The JSF has the opportunity to draw on the lessons learned from past programs as well as on-going cooperative development and production programs […].[91]

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[90] Raymond Franck, Ira Levis, and Bernard Udis, Echoes Across the Pond: Understanding EU-US Defense Industrial Relationships, (Monterey, CA: Naval Postgraduate School, 2008), 59.

[91] Jon A. Schreiber, JSF International Business Strategy, NATO's Nations and Partner for Peace, (November 2002), 164.

As mentioned before, the JSF program, the world's largest and most expensive development program to date is a cooperative program between the U.S. DoD and eight U.S. allied-nations for developing and manufacturing fifth generation fighter aircraft to replace aging inventories. The participant nations are Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey and the United Kingdom.

Commonly, the program is conceived as an international acquisition program meant to attract financial investment and technological innovation from partner countries, as well as to partner early with governments whose military services will likely be users of this state-of-the-art coalition forces platform.[92] The F-35 Lightning II aircraft brings new capability to the air forces, but also serves as a centerpiece for international cooperation.[93]

The JSF Program does not only involve cooperation between the U.S. government and the government of its allies', but also leads to cooperation between prime contractors and the allies' industrial partners. The governments' relationship structure was established through a framework Memorandum of Understanding (MOU) that identifies the roles, responsibilities, and expected benefits for all participants.[94] The relationship between prime contractor and international subcontractors were structured by agreements and licenses. The International Strategy/Cooperative Framework of the program is depicted in Figure 7:

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[92] U.S. Department of Defense, *JSF International Industrial Participation: A Study of Country Approaches and Financial Impacts on Foreign Suppliers,* (Washington, DC.: DoD, June 2003), 2,

http://www.acq.osd.mil/ip/docs/jsf_international_industrial_participation_study.pdf.

[93] Unites States Air Force, *F-35 Centerpiece for International Partnership,* September 28, 2006, http://www.af.mil/news/story.asp?id=123028145.

[94] U.S. General Accounting Office, Acquisition Managing Competing Pressures, GAO-03-1012T , 3.

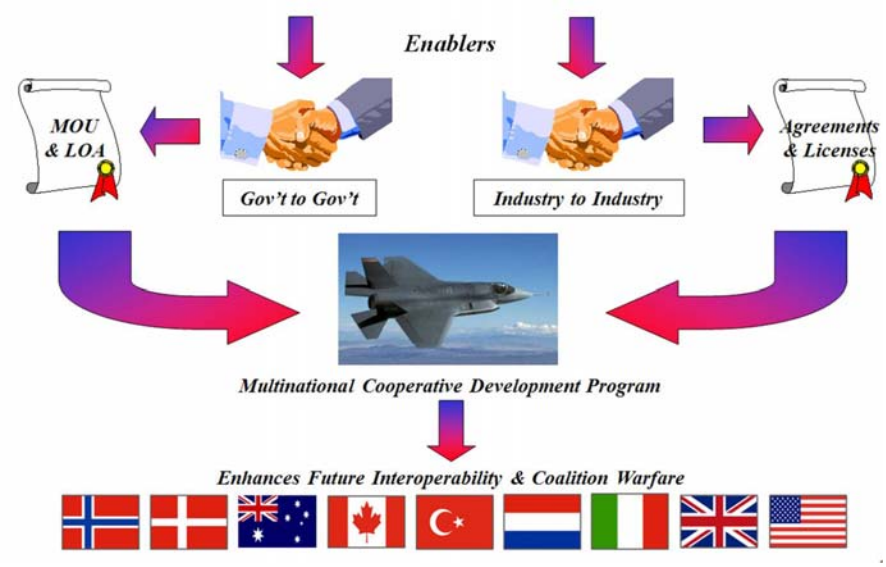

Figure 7. JSF International Strategy/Cooperative Framework. *Source:* Steven L. Enewold, "Joint Strike Fighter Program Briefing," June 8, 2004.

The U.S. and participant nations have different expectations of the JSF program. A GAO report asserts that the U.S. expects to benefit from sharing program costs, gaining access to foreign industrial capabilities, and improving interoperability with allied militaries once the aircraft is fielded. The report points out that the participant nations expect to benefit through defined influence over aircraft requirements and improved industrial relationships with U.S. aerospace companies through access to JSF contractors and subcontracting competitions. The report also states that a major benefit for partners is having their personnel physically located within the program office with access to program information and contractor data.[95]

The report further points out that the JSF program contributes to the U.S.'s armaments cooperation policy. The purpose of the armament cooperation is to increase military effectiveness through standardization and interoperability and to reduce weapons acquisition costs by avoiding duplication of development efforts with U.S. allies. The JSF program supports the policy in the following areas:

[95] U.S. General Accounting Office, Joint Cooperative Program Needs, GAO-O3-775, 1–2.

- Political/military: expanded foreign relations,
- Economic: decreased JSF program costs from partner contributions,
- Technical: increased access to the best technologies of foreign partners,
- Operational: improved mission capabilities through interoperability with allied systems.[96]

2. International Participant Phases and Levels

Rather than representing a full co-development effort, the JSF program could be characterized as a U.S.-led program with significant foreign outsourcing at the second and third tiers.[97]

Unlike previous defense acquisitions, the first cooperative partner participated in the program at the JSF program definition and risk reduction phase in 1996 (even the U.K. had participated in 1995). Then, until 2002, other cooperative partners participated in the program's SDD phase. Joining the JSF program as level one, two, and three partners in the SDD phase was only possible until July 15, 2002. Partner nations were able to withdraw from participation at any time during this phase.[98] The last phase of the program's international aspect is PSDF, and current participant partners entered in the program in 2006 and 2007. A summary of the international program progress is depicted in Figure 8:

[96] U.S. General Accounting Office, Joint Cooperative Program Needs, GAO-O3-775, 4.

[97] Mark A. Lorell, Julia Lowell, Richard M. Moore, Victoria Greenfield, and Katia Vlachos, Going Global? U.S. Government Policy and the Defense Aerospace Industry, (Santa Monica, CA:RAND, 2002), 164, http://stinet.dtic.mil/dticrev/a411882.pdf.

[98] Gerard Keijsper, Lockheed F-35: Design and Development of the International Aircraft, (South Yorkshire, England: Pen & Sword Aviation, 2007), 259.

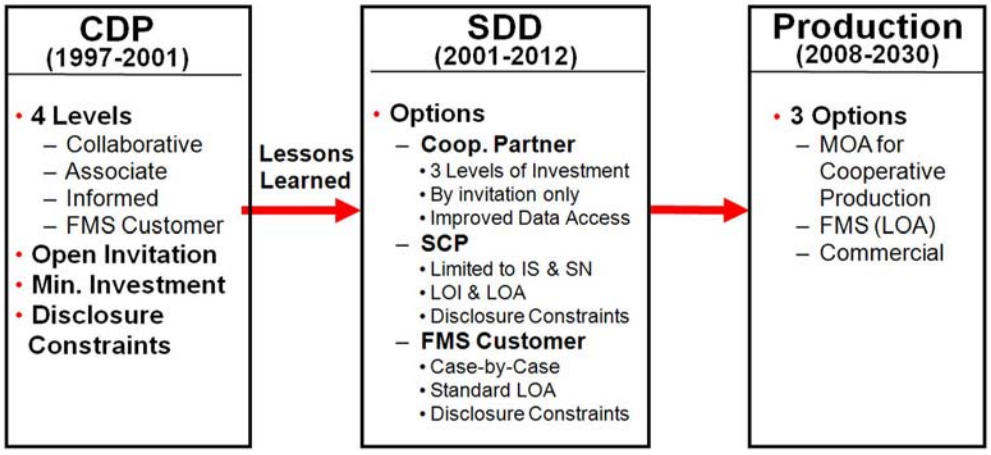

Figure 8. JSF International Program Progression. *Source:* Steven L. Enewold, "Joint Strike Fighter Program Briefing", June 8, 2004.

a. Concept Demonstration Phase Participation (Program Definition and Risk Reduction Phase)[99]

The United Kingdom became a full collaborative partner in the program in 1995. Denmark, Norway, the Netherlands, Canada, and Italy subsequently joined the program as cooperative partners. Singapore, Turkey, and Israel are foreign military sales participants for this phase.[100] There were four levels at which participants joined the JSF program:

- Level I - Full collaborative partner: the United Kingdom was the only participant at this level, committing 200 million dollars for the CDP. The U.K. is thus entitled to full access to program data and structure, as well as the ability to influence requirement definitions and performance characteristics.

- Level II - Associate partner: Denmark, the Netherlands, and Norway formed a group and paid a total of 30 million dollars to participate at this level. These nations are entitled to limited access data and limited requirement influence.

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[99] Keijsper, Lockheed F-35, 257–259.

[100] F-35 Joint Strike Fighter Program Office. JSF History, http://www.jsf.mil/history/his_f35.htm.

- Level III - Informed partner: Canada and Italy participated in this level by paying 10 million dollars each. They are entitled to limited access to program information and representation, but have no influence on requirements.

- Level IV - Foreign military sale partner: Turkey, Singapore, and Israel participated at this level. They are entitled only to negotiate directly with the program office about cost, operational performance, and modeling and simulation studies.

b. System Development and Demonstration Phase Participation

The cooperative nations participated in the program's system development and demonstration phase in three levels based on their financial contributions. Through their participation levels, the participant nations proportionately benefited from the program, including the number of staff representing them in the program office, access to program data and technology, and membership on management decision-making bodies. The last available data suggest that participant nations' financial contributions are over 4.5 million dollars or 10 percent of that times system development and demonstrations phases cost.[101] The advantage of joining the SDD phase was the ability to withdraw without financial penalty. Participation in the SDD phase allowed partner nations to compete for contracts on a "best value" basis.[102] The allied nations' financial contributions, production rates, and partner levels can be seen in Table 9.

[101] U.S. Government Accounting Office. Management of the Technology Transfer Process, GAO-06-364, 3.

[102] Keijsper, Lockheed F-35, 259.

Partner country	System development and demonstration			Production	
	Partner level	Financial contributions (in millions)	Percentage of total costs	Projected quantities	Percentage of total quantities*
United Kingdom	Level I	$2,056	4.96	138*	4.3
Italy	Level II	$1,028	2.48	131	4.1
Netherlands	Level II	$800	1.93	85	2.7
Turkey	Level III	$175	0.42	100	3.2
Australia	Level III	$144	0.33	100	3.2
Norway	Level III	$122	0.29	48	1.5
Denmark	Level III	$110	0.27	48	1.5
Canada	Level III	$100	0.24	80*	2.5
Partners		**$4,535**	**10.93**	**730**	23.0
United States		$36,946	89.07	2,443	77.0
Total		**$41,481**	**100.0**	**3,173**	**100.0**

Table 9. JSF Partner Financial Contributions and Estimated Aircraft Purchases. *Source:* GAO Report, GAO-06-364, 4.

c. Production, Sustainment and Follow on Development Phase

The last phase for participation was the sustainment and follow on development phase. The Netherlands, Canada, Australia, and the United Kingdom participated in this phase in 2006, while Turkey, Norway, Italy, and Denmark participated in 2007. In the PSFD phase, the participant nations committed to buying aircraft. If a nation reverses its decision to purchase the aircraft after participation in this phase, it could be penalized financially.[103]

Unlike the SDD phase, the PSFD phase does not offer levels for participant nations. In signing the PSFD Memorandum of Understanding (MOU), the nations gave details of their procurement plans, including the type of aircraft, numbers of aircraft requested, and timeline for purchasing. The governance structure of the program

[103] Keijsper, Lockheed F-35, 259.

has broadened to allow all participating nations to have a voice in follow-up development decisions. In contrast to the SDD phase, the phase costs will here be divided in a "fair-share" manner based on the proposed purchase amount of the respective nation. Also, unlike the bilateral SDD MOUs, PSFD is an agreement among all partner nations.[104]

d. Initial Operational Test and Evaluation (IOT&E)

The IOT&E phase is a subset of the SDD phase. The cooperating nations are invited to participate in this subpart phase in 2009.[105] The U.K., Italy, and the Netherlands have agreed to participate in the IOT&E program. The U.K. will have the strongest participation in the IOT&E phase. Other partner nations have not yet determined their participation in this phase. The benefits to participation are expedited acquisition of aircraft, pilot training for the test cycle, and access to testing results.[106]

e. Best Value Acquisition Approach

However, unlike other international cooperative programs, the JSF program does not guarantee foreign or domestic suppliers a predetermined level of work based on a country's financial contribution to the program and does not assign any traditional offset arrangements. Instead, foreign and domestic suppliers generally bid competitively for JSF work.[107] The best value approach is used to describe that competitive acquisition approach.

To qualify for participation in the bidding process for JSF subcontracts, international and domestic industrial partners must demonstrate world-class products and technologies representing cost advantages to the program. Once Lockheed Martin and its top-tier partners have chosen a supplier, they will pursue sole source contracts with these companies based on schedule, performance, and cost benchmarks. If the suppliers do not

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[104] Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program, 2009, 9.

[105] SPG Media, Naval Technology, *F-35 Lightning II - Joint Strike Fighter (JSF), USA,* http://www.naval-technology.com/projects/jsf/.

[106] Bolkcom, F-35 Lightning II Joint Strike Fighter (JSF) Program, 2009, 11.

[107] U.S. Government Accounting Office. Management of the Technology Transfer Process, GAO-06-364, 5.

meet these benchmarks, they open themselves to re-competition.[108] Participant nations' motives behind SDD participation, major keys to government approaches, and the partners' concerns are shown in Table 10.

Countries	Primary Motive behind SDD Participation	Major Key to Government Approach to JSF Program	Main Concerns with JSF Program
United Kingdom	Operational requirement	Early commitment to JSF Program	Delayed information disclosure
Italy	Operational requirement	Worked with Lockheed Martin to develop industry support	US contracting practices unfamiliar, Lengthy TAA approvals
Netherlands	Industrial benefit	"Public - Private Partnership"	US sub-tiers unwilling to source work to global suppliers, Lengthy TAA approvals
Canada	Industrial benefit	Pro-active "JSF Canada" organization	"Strategic Sourcing"
Norway	Industrial benefit	Teaming with other partner countries to increase competitiveness	US top tier contractors favor established suppliers
Denmark	Operational requirement	Liaison between Danish industry and Lockheed Martin and sub-contractors	Large companies often absorb upfront development costs
Australia	Operational requirement	Government liaison between Australian industry and program IPTs	Export regulations - TAAs and GPA
Turkey	Industrial benefit	MOD liaison between industry and Lockheed Martin	Lack of communication

Table 10. Summary of Country Strategies and Concerns. *Source:* U.S. DoD, JSF International Industrial Participation, 13.

[108] U.S. Department of Defense, *JSF International Industrial Participation*, 13.

3. The JSF Program International Industrial Participation[109]

In June 2003, the U.S. DoD issued a study (cited above) that analyzed the motivations behind participant nations' industrial participation, their concerns, and the program's financial impact. To understand the nations' concerns and expectations, a summary of the study's findings are attached below:

a. The United Kingdom

Key Features of Government Approach:

- Royal Air Force/Navy operational requirements are the key reason for JSF participation.
- Early involvement in the program has helped U.K. firms to gain entry to the program.
- The U.K. government and industry are committed to best value strategy; the government trusts industry to fight for work while it acts to ensure a "level playing field."

Concerns:

- Lack of disclosure of technical information has potential to limit industrial competitiveness.
- The international nature of JSF exposes the U.K. to potential risks, particularly cost impacts of U.S. reprogramming or Congressional intervention via "Buy-America" legislation.

Financial Impact:

- Incremental earnings attributable to JSF work will likely run well into the billions in U.S. dollars over the life of the program, bringing great vitality to U.K. industry,
- Nominal return on investment is likely to be very high, perhaps exceeding 21 dollars for every dollar of direct program investment over the life of the program.

[109] U.S. Department of Defense, *JSF International Industrial Participation*, 16–70.

Primary Reasons for Participation

- To meet operational requirements of RAF and the Royal Navy,
- To achieve operational commonality with the United States,
- To achieve an affordable Air System through economies of scale.

b. Italy

Key Features of Government Approach:

- Air Force/Navy operational requirements are the key reason for JSF participation.
- Italian JSF investment (1.028 billion dollars) is funded by the Ministry of Defense, with support from Ministry of Productive Activities,
- Lockheed Martin-Italian Ministry of Defense LOIs and MOU outlining expected JSF participation with Italian industry preceded Parliamentary approval.

Concerns:

- Late commitment to SDD might have limited potential Italian contract wins.
- Italy believes that several issues have impaired their SDD participation on a "level playing field" basis.
- Italian industry has been upset by short RFP response times, and is stunted by a lack of familiarity with the "best-and-final-offer" concept (no interim negotiations) – both standard US contracting practices.
- Limited effectiveness of GPA has forced firms into lengthy TAA processes.

Financial Impact:

- Italy will likely see a nominal return of over 476 percent on their SDD investment – ~25 percent compounded annually – over the course of SDD, LRIP, and FRP.

Primary Reasons for Participation

- Italian Air Force & Italian Navy requirement for future tactical fighters,
- To facilitate Italian industrial participation in JSF program.

c. The Netherlands

Key Features of Government Approach:

- During CDP, JSF was selected by the Dutch government as one of two aircraft platforms upon which to build the Dutch aerospace industry of the future.
- Early (1997) financial support from the Dutch government to Dutch industry promoted JSF participation.
- A Public-Private Partnership (PPP) provided government sponsorship of SDD investment in exchange for a 3.5 percent tax on all Dutch JSF production and support revenues in order to repay SDD investment.
- JSF CDP and SDD efforts are led by the Ministry of Economic Affairs, with key input by industry, MoD, and the Royal Netherlands Air Force.
- The Dutch JSF organization intended to act as a "first responder" contact with Lockheed Martin and other JSF contractors and an "enabler" of business relationships for Dutch industry; however, it was unable to prevent two non-compliant bids.

Concerns:

- Dutch companies feel that they cannot compete on a "level playing field" with American counterparts due to geographic, financial, export control, and security of supply limitations.
- The Dutch Parliament's early concerns related to return on investment is a constant threat to future participation in JSF program.

Financial Impact:

- The Netherlands is expected to earn a nominal return on their SDD investment of well over 700 percent – a ~40percent annually-compounded return.

Primary Reasons for Participation

- To use JSF as the military aircraft platform upon which the Dutch aerospace industry would be technically based for the future,
- To evaluate JSF as a potential replacement for F-16.

d. Canada

Key Features of Government Approach:

- The Department of National Defense and Industry Canada took the lead in championing Canadian participation in the JSF program through the innovative organizational structure of "JSF Canada."
- JSF Canada pro-actively sought opportunities for Canadian industry by meeting with major JSF contractors and surveying the Canadian industrial base.
- Canada hopes to foster best value performance on a global scale through partnerships with other JSF countries.

Concerns:

- "Strategic sourcing" may damage the credibility of best value programs in future Canadian parliamentary debates on JSF and other programs that are similarly structured, e.g., Multi-Mission Maritime Aircraft.
- Canada's ITAR exemption has not been used, which has created delays in obtaining clearances to access technical RFP information.

Financial Impact:

- Canada will likely see an annual compounded rate of return on their SDD investment greater than 75 percent over the life of the JSF program.
- Technical knowledge gained through SDD is expected to fuel future earnings through "spin off" products.
- The "JSF supplier" label will boost earnings from other programs due to marketing appeal.

Primary Reasons for Participation

- To facilitate Canadian industrial participation in the JSF program,

- To evaluate JSF as a potential candidate for the Canadian Forces,
- To promote interoperability between U.S., U.K., and Canadian militaries,
- To gain insight into U.S. procurement methodologies and best practices.

e. Norway

Key Features of Government Approach:

- Potential industrial benefits spurred initial involvement in CDP; potential operational requirements surfaced later.
- Government/industry groups formed to look at the overall industrial implications of defense programs.
- Norwegian government is not organized to assist industry in winning JSF work.
- Norway is forming international partnerships with Canada and Denmark.

Concerns:

- Norway lacks a "level playing field," as Lockheed Martin and their first tier subs tend to favor pre-existing supplier relationships.
- Lockheed Martin's new "Strategic Sourcing" plan is not the answer.

Primary Reasons for Participation

- To facilitate Norwegian industrial participation in JSF program,
- To evaluate JSF as a potential Norwegian Air Force purchase.

f. Denmark

Key Features of Government Approach:

- Denmark is hoping to leverage its relationship with Lockheed Martin and its prior F-16 program experience to win JSF contracts.

- Denmark possesses strong industrial support, including co-funding of SDD investment.
- Denmark believes that the primary benefit to program participation is in acquiring a replacement platform for its current F-16 fleet.
- Political opposition has forced Danish defense suppliers to lobby for JSF program participation.
- Danish industry and government officials have worked diligently to organize marketing opportunities for Danish defense companies and capabilities.

Concern:

- In the best value contracting process, larger companies often absorb upfront development costs in order to under-price and eliminate competition, allowing them to capture windfall profits during production phases.

Primary Reasons for Participation

- To replace current the F-16 fleet with F-35 aircraft,
- To support the Danish defense industry,
- To gain understanding of the F-35 platform and program.

g. Australia

Key Features of Government Approach:

- Australia is taking a combined government-industry approach to maximize opportunities for Australian industry within the best value model.
- Australia has formed a JSF program office to coordinate both the industry and capability aspects of the project.
- Australia has created a JSF industry team to help maximize opportunities for national industry.
- Australia is looking to team with U.S. companies and companies from other partner countries where of mutual advantage.

Concerns:

- Australia has been unable to bid on some JSF contracts due to the lengthy TAA execution process.
- Australian companies sometimes face difficulty competing against larger U.S. and Canadian companies that may subsidize their JSF programs in the SDD phase. Australia believes that strategic sourcing contracts will help overcome this somewhat, but is still very much in favor of the best value arrangements.

Primary Reasons for Participation

- To facilitate Australian industrial participation in JSF,
- To evaluate JSF as a potential platform for Australian forces.

h. Turkey

Key Features of Government Approach:

- The Turkish MoD chose to become a partner in the JSF program in order to support its defense industry and eventually replace its fleets of F-4s, F-5s, and F-16s.
- The MoD is working to bring together respective points of contact in the Turkish defense industry and JSF contractors.
- The Turkish government provides development funds to financially support companies that secure JSF opportunities.

Concern:

- Until a recent meeting with senior Lockheed Martin and DoD officials, Turkey believed that it lacked information on the complete universe of available JSF contracts. As communication has since improved, Turkey believes that it is now better positioned to capitalize on its position as a JSF partner-level participant.

Primary Reasons for Participation

- Positive effect on industry in terms of increased revenues, jobs, and technological expertise,
- The upcoming need to replace existing fighter aircraft.

G. CONCLUSION

This chapter reviews literature relevant to the multi-national cooperative acquisition aspect of the JSF program. The review is highly concentrated on literature pertaining to the acquisition strategy and budget details of the program as well as participation by allied nations. However, while there is much literature concerning the JSF program, there is only one study regarding allied nations' industrial participation in the program. This study was prepared by the U.S. DoD in June 2003, and titled "JSF International Industrial Participation: A Study of Country Approaches and Financial Impacts on Foreign Suppliers."

U.S. DoD and GAO studies have consistently estimated similar cost and budget figures; however, there is inconsistency between cost and budget timing. The DoD's 2005 and 2006 cost and budget estimates match the GAO's 2006 and 2007 cost estimates, respectively. For example, the DoD's 2005 estimate is 276.4, and the GAO's 2006 estimate is 276.4.

All studies and reports agree on the cost increase and schedule delays. As mentioned in the budget section, affordability is one of the pillars, but since 2001, the unit cost of the aircraft has increased by roughly 50 percent. Also, full production outset was planned for 2012 in 2001, but the program schedule has been delayed by two years and is now rescheduled for 2014.

As mentioned in the DoD's studies of the allied nations' industrial participation in the program, multi-national cooperation effectively mitigates the burden of cost for individual nations, but has also resulted in unprecedented problems such as technology transfer and ineffective bidding on subcontracts. In summary, all participant nations have different expectations and concerns.

After reviewing the program's history, acquisition strategy, budget details, and issues of international participation, the next chapter analyzes the acquisition aspect of this international aircraft design and development program.

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III. ANALYSIS OF THE JSF PROGRAM'S INTERNATIONAL COOPERATIVE ACQUISITION STRATEGY

The JSF program is the largest and most expensive international design, development, production, and procurement program in the history of the U.S. DoD, and for that matter, the world. According to GAO reports, the JSF program's procurement volume is 3173 aircraft (2443 aircraft for the U.S. and 730 aircraft for eight allied nations). Currently, the estimated average acquisition unit cost of F-35s is 121.60 million dollars; the estimated total acquisition cost is over 386 billion dollars. According to the last assessment made in 2007, the estimated life cycle cost is more than 1 trillion dollars just for the U.S. DoD. As the numbers demonstrate, the JSF program is not only critical to the U.S. and its eight allied nations' future force structures and military capabilities, but is also critical to all world defense industrial bases.

The main purpose of the JSF program is to replace U.S. and its allies' aging aircraft with affordable, lethal, supportable, and stealth fifth generation aircraft. In addition to gaining a superior aircraft, the U.S. and its eight allies expect to realize a variety of benefits from this international cooperation program. The U.S. expects to defray the development and production cost, to benefit from nations' aerospace technology and experience for the high technology aircraft in its Navy, Air Force, and Marine Corps, and to improve interoperability with its allies once the aircraft is fielded. The allied nations expect to acquire an advanced aircraft that they cannot afford to develop and produce on their own, to realize a return on their investment by bidding on the subcontracts, and to benefit from reaching aerospace technology and data.

As mentioned in the U.S. DoD International Cooperation Handbook, international armaments cooperation is a complicated business and requires consideration of a series of complex national and international interrelationships. In addition to the intrinsic complexity of international cooperation, the inherent complexity of this ambitious and multifaceted project has resulted in a more complex JSF program, and has obligated the U.S. to implement an unprecedented acquisition strategy. The U.S. DoD's new

acquisition strategy to develop and product JSF aircrafts first includes the allied nations' participation in the program from inception of the concept development phase. No other countries or defense contractors have hitherto been invited or allowed to participate in a weapon or defense systems program from the concept development and design phase. Second, a best value acquisition strategy has been implemented for subcontracting, instead of traditional work share programs. Third, instead of coequal program participation, the program has developed a new partnership approach that requires participant nations' commensurate representation, gives them influence in the program, and grants benefits dependent on their financial contributions. In these aspects, the JSF program is unique among the international cooperative armaments program; there are no other programs that can be used as a model for the JSF program.

The U.S. DoD hopes that the JSF program's unprecedented acquisition strategy establishes a model for prospective international cooperative acquisitions. Thus, the U.S. DoD and the JSF Program Office have envisioned that the JSF program will "be the model acquisition program for joint services and international cooperation to deliver to aircraft an affordable and effective next generation strike fighter weapon system and sustain it worldwide."[110]

This chapter analyzes the core objectives of the JSF program, international partners' earlier involvement in the program, the best value acquisition approach, the leveled partnership strategy, affordability, and reasons for cost increase and schedule delays.

A. INTERNATIONAL ARMAMENTS COOPERATION AND JSF PROGRAM

1. The Objectives of the Multi-National Armaments Cooperation

Over the past few decades, the increasing cost of new weapons systems led the U.S. and its allies' policymakers to pursue collaborative international arrangements to

[110] F-35 Joint Strike Fighter Program Office, JSF Program Brief, 13 September 2005, http://www.jsf.mil/downloads/documents/AFA%20Conf%20-%20JSF%20Program%20Update%20-%2013%20Sep%2005.PDF.

share the cost of development and production. In addition to reducing cost, international armaments cooperation programs have distinctive benefits such as providing interoperability between allied forces, providing greater political integration through shared training and doctrine,[111] and enabling technology sharing.

Current U.S. DoD policy[112] highly promotes international cooperative acquisition, technology and logistics programs, projects, and activities with its allies. The U.S. DoD believes that international cooperative acquisitions enable the warfighter to be well prepared and supported for military operations, including coalition operations to defeat any adversary on any battlefield. Also, it is believed that well-constructed international cooperative agreements and programs strengthen the U.S. and its allies' defense industrial base by providing reciprocal access to each other's defense markets. The U.S. DoD International Armaments Cooperation Handbook states that establishing and maintaining cooperative relationships with allied nations is critical to achieving interoperability of equipment and services to be used by the armed forces of the United States and coalition partners. Furthermore, cooperative relationships are vital to achieving access to technology from sources worldwide, economies of scale, and expanding the U.S.'s influence in critical areas of the world. Accordingly, the U.S. International Armaments Cooperation policy strongly encourages the DoD to continue pursuit of international cooperative activities. DoD Directive 5000.1 thus states that all program managers shall pursue international armaments cooperation to the maximum extent feasible, consistent with sound business practice and with the overall political, economic, technological, and national security goals of the U.S.[113]

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[111] Mark Lorell and Julia Lowell, Pros and Cons of International Weapons Procurement Collaboration (Santa Monica, CA: RAND, 1995), ix.

[112] Office of the Under Secretary of Defense for Acquisition, Technology & Logistics, USD(AT&L), International Armaments Cooperation Handbook (Washington D.C. 2009), 8, http://www.acq.osd.mil/ic/handbook.pdf.

[113] Office of the Under Secretary of Defense for Acquisition, Technology & Logistics USD(AT&L), DoD Directive 5000.01. Defense Acquisition System (Washington D.C. Certified in November 20, 2007), Enclosure1, 5.

According to the U.S. DoD International Armaments Cooperation policy, the core objectives of armaments cooperation are categorized in five subgroups: operational, economical, technical, political, and industrial. Expected benefits from these core objectives are:

- **The Operational objective** is to increase military effectiveness through interoperability and partnership with allies and coalition partners.
- **The Economic objective** is to reduce weapons acquisition costs by sharing costs and economies of scale, and by avoiding duplication of development efforts with our allies and friends.
- **The Technical objective** is to access the best defense technology worldwide and help minimize the capabilities gap with allies and coalition partners.
- **The Political objective** is to strengthen alliances and relationships with other friendly countries.
- **The Industrial objective** is to bolster domestic and allied defense industrial bases. After the end of the Cold War, the U.S. recognized that armaments cooperation programs offered new and broader opportunities for promoting U.S. security.

2. The Objectives of the International Cooperative Acquisition of the JSF Program

From the inception of the JSF program, the U.S. DoD has committed to design, develop, and produce JSF aircraft with its eight trusted allied nations in order to gain the benefits of the international armament cooperation. In 2003, Alfred G. Volkman, U.S. Director of the International Cooperation Office of the Under Secretary of Defense (AT&L), articulated the reasons behind the JSF's international cooperation strategy. In his view, the strategy would increase military effectiveness through standardization and interoperability and reduce weapons acquisition costs by avoiding duplication of development efforts with U.S. and its allies, as ruled by the U.S. DoD policy. In the hearing before Congress, he also stated that the ongoing JSF cooperative SDD phase activities with partner nations would accomplish the core objectives outlined in the International Armament Cooperation Handbook. There are four objectives of the JSF

program. The political/military objective is to enhance defense relationships with key allies. The economic objective is to decrease JSF program costs through partner contributions. The technical objective is to increase access to the best technologies of foreign partners. Finally, the operational objective is to improve mission capabilities through interoperability with allied forces in future coalition operations.[114]

The JSF program's international cooperative acquisition strategy's core objectives are here analyzed in further detail.

a. The Political/Military Objective

The Political and Military objective of the JSF program is to enhance defense relationships among the U.S. and its key allies. In other words, the U.S. strives to tighten its relationship with its allies and have more powerful air forces to cooperate in future operations.

According to the U.S. DoD's International Armaments Cooperation Handbook, and as demonstrated in Figure 9, the highest achievement in armaments cooperation is cooperative research and development programs. The JSF program strongly promotes research and development issues; thus, the JSF program represents the highest level of international armaments cooperation, and the U.S. expects benefits greater than those offered by other types of cooperation.

[114] U.S. Congress. Senate, Subcommittee on National Security, Emerging Threats, and International Relations of the Committee on Government Reform, Joint Strike Fighter International Cooperative Program, July 21, 2003.

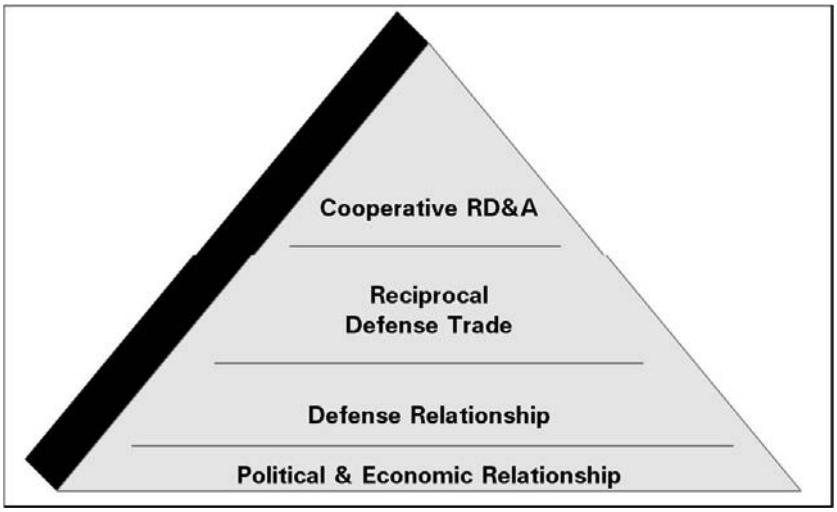

Figure 9. Hierarchy of Relationships Leading to Armaments Cooperation. *Source:* U.S. DoD International Armaments Cooperation Handbook, 6.

The JSF program began in 1994, but most of the participating allied nations joined the program around 2002. The last aircraft will be delivered in 2034, and the F-35s will be in the service until 2064. Because of the JSF's sophisticated acquisition strategy, which results in distribution of the production facility to nations all over the world, participant nations are obliged to retain involvement in the program during the life cycle of the aircraft, which is more than 60 years. Undoubtedly, the program will increase nations' goodwill relationships and serve as an impetus to other defense cooperative acquisitions, but it will also decrease nations' independence. An e-mail received on August 17, 2009 from the main contractors Lockheed Martin and Northrop Grumman mention that over one hundred defense subcontracts from different countries are working to develop and produce the JSF aircraft. Doubtlessly, one hundred subcontractors from various countries cause a complex subcontracting acquisition strategy and increase the participant nations' dependability on each other. The nine allied nations must rely on each other in order to afford and support the F-35s. On the other hand, in political relationships, nations are allies only until their common interests clash. Since nation's common interests can change in less than a decade, 60 year partnerships are politically optimistic.

As an example, in 1911 Turkey had a miserable experience involving political change and international partnerships. In that year, the Turkish government placed an order for two warships from the U.K. The warships, "Reşadiye" and "Sultan Osman," were built by the U.K. in 1914. The Turkish government paid for the warships at a cost of 7.000.000 in gold, but on the last day of the contract the U.K. government refused delivery of the warships unless the Turkish government would agree to some political conditions. The resulting conflict continued between Turkey and the U.K. for many years.[115]

Long term international cooperative acquisitions require stable and dedicated political relationships among allies. While there is no current instability among JSF participant nations, any major future instability among them can endanger the affordability of the aircraft, cause schedule delays, or affect the supportability of aircraft until a solution is found.

b. The Economic Objective

Allied nations participated in the program's SDD phase in three levels and cumulatively contributed 4.5 billion dollars to the program, receiving commensurate benefits. The allied nations' contribution represents 10.9 percent of total SDD funding. The U.K. is a level I partner and contributed 2 billion dollars, 45 percent of the eight allied nations' contributions and almost five percent of the entire program. Italy and the Netherlands are level II, while Australia, Canada, Denmark, Norway, and Turkey are level III partners in the program. Allied nations' financial contributions are shown in Table 9.

To defray the costs of this affordable yet highly capable aircraft, the U.S. DoD has invited its allies to become program partners. Apart from the common desire to develop and field the aircraft, the U.S. and other allies have different expectations of the program.

[115] Rifat Uçarol, Siyasi Tarih 1789–2001, (İstanbul: DER Yayınları, 2008), 566.

(1) U.S. Economic Objectives. The U.S. has two aims for the research and development (R&D) aspect. First, the U.S. does not want to fund technology which has already been developed by allied nations in consortiums to which the U.S. does not belong. The F-35B's short take off technology, for instance, is already in use by the U.K., and the U.S. does not own the proprietary data. The technology is provided by the U.K. Secondly, the U.S. wants to share research and development costs with allied nations for innovative parts of aircraft. Allied nations have thus contributed 4.5 billion dollars, almost 11 percent of the SDD phase, to share these costs.

Additionally, the U.S. wants to benefit from economies of scale by sharing fixed costs, thereby reducing costs in the long term. International participation to the JSF program provides significant benefits of the economies of scales. The program will produce 3173 aircraft before the year 2034, 2443 of them for the U.S. and 730 for the allied nations. The Allied nations will procure 23 percent of the manufactured aircraft. The agreement will provide benefits of economies of scale for the lead country, the U.S.

Lastly, allied nations earlier involvement in the program creates a valuable market for the U.S. and the prime contractor. The U.S. lured the potential customer to contribute at the outset of the program. The participant nations adapted to the JSF program until 2006, developing an industrial relationship with the prime contractors and with the U.S. DoD. Then, in 2007, they committed to procure aircraft without accurate test results and current acquisition costs. Hence, the U.S. marketed 23 percent of the JSF aircraft before the project's maturity.

(2) Allied Nation's Economic Objectives. All of the allied nations have noteworthy economic expectations of the JSF program. The U.S. DoD's JSF International Industrial Participation Study[116] shows that the Netherlands, Canada, Norway, and Turkey are primarily motivated by industrial, or economic, benefits. However, the U.K., Italy, Denmark, and Australia are primarily motivated by operational factors; they expect a return on their investment.

[116] U.S. Department of Defense, *JSF International Industrial Participation,* .6.

The JSF program provides an opportunity for allied nations to realize a return on their investments by bidding competitively on the subcontracts. According to the DoD's JSF International Industrial Participation study, the annually-compounded return from the partners' SDD investments range from 25 percent to over 100 percent. This means that the participant nations will potentially earn between five and 40 dollars of revenue in return for every one dollar invested into the program, as shown in Table 11. While Canada's dollar-for-dollar return is nearly twice that of the U.K. due to their relatively small partnership investment, the U.K.'s annually-compounded rate of return is much higher due to the earlier timing of industrial revenues.[117]

SUMMARY OF PARTNER COUNTRY RETURN POTENTIAL

Summary (US$M)	SDD - FRP Revenues 2002-2026	Partnership Investment 2002-2026	Nominal Return 2002-2026	Annually Compounded Rate of Return 2002-2026
United Kingdom	$43,456.5	$2,056.0	**2113.6%**	109.2%
Italy	4,896.4	1,028.0	**476.3%**	23.8%
The Netherlands	5,741.7	800.0	**717.7%**	38.1%
Canada	3,910.8	95.0 [1]	**4116.6%** [2]	66.7% [3]

Table 11. Summary of Partner Country Return Potential. *Source:* U.S. DoD International Armaments Cooperation Handbook, 4.

In addition to direct economic benefits, the JSF acquisition program provides indirect economic benefits to the participant nations. First, thanks to international armaments cooperation, the allied nations may become acquainted with the others' defense industries and capabilities for prospective co-operations. Thus, the participant nations can find a market to sell or buy defense systems. For example, Turkey's TUSAS Engine Industry (TEI) first had a contract to manufacture parts for the General Electric F136 engine and the JSF power plant for Lockheed Martin. After

[117] U.S. Department of Defense, *JSF International Industrial Participation,* .4.

successful production of TEI, it won a contract to provide design engineering and analysis for the F136 as well as other General Electric military and commercial engines. Later, GE awarded TEI a 700 million dollar manufacturing contract for commercial engine parts.[118]

Second, the JSF's international cooperative acquisition strategy prevents wasted duplication of research, thus avoiding unnecessary development costs. If one nation wants to design and develop an aircraft alone, it must bear the entire burden of the program's budget, including costly research and development and indirect and overhead costs. Conversely, the JSF's acquisition strategy encourages nations to share the research and its cost.

c. Technical Objective

The technical objective of the JSF program is to increase access to the best technologies of allied partners. The U.S. DoD wants to decrease the cost of research and development by obtaining existing airspace technology from its allies. For example, F-35B's short takeoff and vertical landing technology and the lift fan system that powers the same U.S. Marine and U.K. variant are examples of technology that transferred from allied nations.[119] On the allied nations' side, the program is designed to offer participant nations the benefit of increased access to the programs and contractor information by virtue of their early participation in it,[120] depending on their participation levels. However, GAO reports issued in 2003 (GAO-03-775) and in 2007 (GAO-07-360) show that the participant nations have not been satisfied with the shared data and technology. These reports point out the participant nations' concerns about U.S. oriented technology transfer problems. The participant nations complained about the U.S.'s reluctance to share key technologies and some software codes. Some press reports have indicated that a

[118] Lale Sariibrahimoglu, "Turkey's TEI to make JSF Parts," Jane's Defense Weekly, Ankara, November 22, 2006.

[119] U.S. Congress. Senate, Hearing, Joint Strike Fighter International Cooperative Program, July 21, 2003.

[120] U.S. General Accounting Office, Joint Cooperative Program Needs, GAO-O3-775, 12.

number of partner nations have threatened to withdraw from the program because of frustrations over work share and technology transfer issues.[121] The British press has strongly criticized U.S. reluctance to provide key technologies, particularly the critical software codes, to Britain. At the beginning of 2006, the U.K. mentioned a potential withdraw from the program. On May 26, 2006, then-U.S. President George Bush and then-British Prime Minister Tony Blair issued a joint statement in Washington, resolving to iron out long-standing disagreements. "Both governments agree that the U.K. will have the ability to successfully operate, upgrade, employ, and maintain the Joint Strike Fighter such that the U.K. retains operational sovereignty over the aircraft," the two leaders said in a statement.[122] Technology sharing is the most frustrating and long-standing problem with the JSF program. The complexity of the high technology involved makes the technology transfer issues even more difficult. The JSF program consists of extremely complex aircraft technology, including 22.9 million lines of software programming (approximately 7.5 million lines are aircraft software code and the remainder is associated with logistics, training, and support systems).[123] Recent evidence suggests that the U.S. DoD has developed an effective strategy to share technology with participant nations. Nevertheless, it is difficult to satisfy all nations that have contributed varying program funding amounts and are expecting significant technology transfers. The JSF program demonstrates that technology sharing will likely remain a problem for prospective international cooperative acquisitions unless nations have equally shared in the cost and technology.

d. The Operational Objective

The operational objective of the JSF program is to improve mission capabilities through interoperability with allied forces in future coalition operations. The

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[121] Ronald O'Rourke, F-35 Joint Strike Fighter (JSF) Program: Background, and Issues for Congress, CRS Report RL30563, (Washington DC: CRS, June 18, 2009), 9, http://ftp.fas.org/sgp/crs/weapons/RL30563.pdf.

[122] Jason Sherman, "U.S., U.K., Reach JSF Agreement," InsideDefense.com, NewsStand, August 02, 2006, http://www.military.com/features/0,15240,108100,00.html?ESRC=eb.nl.

[123] U.S. General Accounting Office, Joint Cooperative Program Needs, GAO-O3-775, 12.

JSF will increase interoperability[124] through system commonality among allied air forces. Three version of the JSF fighter share a 70 to 90 percent common airframe to provide interoperability and to reduce production and maintenance costs.

DoD 5000.1 defines the concept of interoperability: "Systems, units, and forces shall be able to provide and accept data, information, materiel, and services to and from other systems, units, and forces and shall effectively interoperate with other U.S. Forces and coalition partners.[125]"

Similarly, U.S. Public Law 10 U.S.C 2457 states: "It is the policy of the United States to standardize equipment, including weapons systems, ammunition, and fuel, procured for the use of the armed forces of the United States stationed in Europe under the North Atlantic Treaty or at least to make that equipment interoperable with equipment of other members of the North Atlantic Treaty Organization."

DoD 5000 series mentions interoperability as a major design consideration affecting the acquisition strategy, and stipulates that all acquired systems shall be interoperable with other U.S. and allied defense systems. Thus, the JSF program is designed and developed to exchange information, materiel, and services among the JSF operator air forces during future coalition operations.

Interoperability is required by U.S. law and highly stressed by U.S. DoD policies. The JSF aircraft has been designed as an interoperable weapon system for the allied nations. Not surprisingly, as a result of their experiences in the Gulf War, the U.S. and the U.K. are two countries who have a focus on interoperability. Both countries know that the necessary synergy required to fight an enemy cannot be reached if coalition forces possess different systems and doctrines. According to a joint statement by

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[124] Lockheed Martin's brochure about F-35s states: "Interoperability: In the battlespace of the future, information is power. The F-35 is the first fighter in history specifically designed to be a key net-enabling node in a system of systems – a lethal information gatherer and transmitter in a vast network of coalition assets. Its tremendous processing power, open architecture, powerful sensors, information fusion and flexible communications links make the F-35 an indispensable tool in future homeland defense and joint/coalition warfare and major combat operations." Please see: http://www.lockheedmartin.com/data/assets/corporate/press-kit/F-35-Brochure.pdf.

[125] Office of the Under Secretary of Defense for Acquisition, Technology & Logistics USD(AT&L), DoD Directive 5000.01. Defense Acquisition System (Washington D.C. Certified in November 20, 2007), Enclosure1, 7.

President Bush and Prime Minister Blair on May 26, 2006, both held "a shared view that we need to continue to strengthen and deepen the relationship between our defense establishments to achieve fully interoperable forces and to leverage the respective strengths of the U.S. and the U.K. industries."[126]

3. Common Interests of the Allied Nations

The common interests of the U.S. and eight participant nations are listed in the MOU of PSFD of the JSF program signed by the nations' representatives. These common interests are:

- Recognizing the benefits to be obtained from international cooperation regarding standardization, rationalization, and interoperability of military equipments;
- Desiring to improve their mutual conventional defense capabilities through the application of emerging technology;
- Desiring to cooperate in the production, sustainment, and follow-on development of the JSF to satisfy similar operational requirements;
- Recognizing the benefits of continued cooperation within the JSF program, and seeking to capitalize on the lessons learned from their previous experiences in this and other international cooperative programs;
- Seeking to establish a model for international cooperative acquisition programs;
- Affirming their intent to use their best efforts to maximize the benefits of international cooperation;
- Seeking to establish a robust vehicle of cooperation that will span the life cycle of the JSF Air System;

[126] Keri Smith, "UK and US Reach Defense Co-operation Accord," Jane's Defense Industry, July 1, 2007.

- Recognizing the importance of technological and industrial cooperation to the national security of all participants and seeking to reduce barriers to that cooperation between the participant; and

- Recognizing that industrial participation will be an important parameter in the participants' various national decision-making processes.

As seen above, the common interests of the participant nations are derived from the program's core objectives. Economic interests of the participant nations outweigh the other program objectives. For that reason, the JSF program can be seen as an economic cooperation rather than a political coalition seeking to establish a model for international cooperative acquisition programs, as promoted by the U.S. and eight allied nations.

B. BEST VALUE ACQUISITION VERSUS OFFSET AGREEMENTS

One of the unprecedented features of the JSF acquisition strategy is the best value acquisition approach.[127] Jon A. Schreiber, ex-Director of the JSF International Program, defines best value as "one of the major tenets of this program which allows for fair and open competition in the globe marketplace." The JSF PSFD MOU defines best value as "maximizing affordability consistent with broader project objectives." GAO reports expound upon this understanding, defining best value as a "competitive approach which does not guarantee foreign or domestic suppliers a predetermined level of work based on country's financial contribution to the program." Implementing a best value approach means moving away from traditional offset agreements and developing completely new, more competitive acquisition strategies for the JSF acquisition and prospective cooperative acquisitions.

According to the U.S. Bureau of Industry and Security, offsets in defense trade are industrial compensation practices required as a condition of purchase in either government-to-government or commercial sales of defense articles and/or defense

[127] Best value defined here and at the Federal Acquisition Regulation (FAR) is not same. FAR describes best value as "the expected outcome of an acquisition that, in the government's estimation, provides the greatest overall benefit in response to the requirement."

services as specified in the International Traffic in Arms Regulations. Offset agreements are commercial contracts between a defense firm and a foreign government.[128] Offset activities can take many forms; they might be directly related to the purchased defense system and related services, or they might involve activities or goods unrelated to the defense system. Developed countries with established defense industries use offsets to channel work or technology to their domestic defense companies. Countries with newly industrialized economies are utilizing both military and commercial related offsets that involve the transfer of technology and know-how.[129]

Offset agreements in international trade became ubiquitous in sales of technologically advanced equipment in the late 1960s and early 1970s.[130] These agreements have also served in important foreign policy and national security objectives of the U.S., such as increasing the industrial capabilities of allied countries, standardizing military equipment, and modernizing allied forces.[131] However, the U.S. government's current policy on offsets in defense trade states that the government considers offsets to be "economically inefficient and trade distorting," and prohibits any agency of the U.S. government from encouraging, entering directly into, or committing U.S. firms to any offset arrangement in connection with the sale of defense articles or services to foreign governments.[132]

A report prepared for the U.S. Congress by the U.S. Bureau of Industry and Security articulates the forces behind changes in policy regarding offset agreements:

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[128] U.S. Department of Commerce, Bureau of Industry and Security, Offsets in Defense Trade, Fifth Study, (Washington D.C.: GPO, May 2001), v, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA393441&Location=U2&doc=GetTRDoc.pdf.

[129] U.S. Department of Commerce, Bureau of Industry and Security, *Impact of Offsets in Defense Trade: an Annual Report to Congress*, http://www.bis.doc.gov/defenseindustrialbaseprograms/osies/offsets/default.htm.

[130] Franck, Levis, and Udis, Echoes Across the Pond: Understanding EU-US Defense Industrial Relationships, 34.

[131] Ibid.

[132] U.S. Department of Commerce, Bureau of Industry and Security, Offsets in Defense Trade, Thirteenth Study,(Washington D.C.:GPO, December 2008), i, http://www.bis.doc.gov/defenseindustrialbaseprograms/osies/offsets/13th_report_to_congress.pdf.

> Defense export sales are an important component of U.S. defense contractors' revenues and to U.S. foreign policy and economic interests. Exports of major defense systems help lower overhead costs to the DoD on common defense programs and help maintain production facilities and workforce expertise for current and future U.S. defense requirements. Exports also provide additional business to many U.S. subcontractors and lower-tier suppliers, promote interoperability of defense systems between the United States and friends and allies, and contribute positively to U.S. international trade account balances. However, when an offset agreement requires a high proportion of subcontracting, co-production, licensed production, or purchases, it can negate some of the economic and industrial base benefits accrued through the defense export sale. U.S. defense subcontractors and suppliers, and in some cases portions of the prime contractor's business, may also be displaced by offset transactions.[133]

The U.S. government contends that offset agreements should largely be limited to short, build-to-print production runs for a limited quantity of aircraft.[134] Offset agreements are not suitable for complex acquisitions such as the JSF program, which requires a high proportion of subcontracting and broad allied nations' participation.

To avoid the drawbacks of offset agreements, the U.S. DoD proposed the best value acquisition approach for the JSF program. A best value acquisition approach, unlike offset agreements, does not guarantee any agreements between the U.S. and participant nations for predetermined work share on the JSF program based on a nation's financial contribution to the program. Rather, the approach requires competition among the nine participant nations' defense industries to reach best value. GAO reports state that the U.S. DoD and the JSF Program Office expect that using a competitive contracting approach, without prescribed work share for partner countries, will also assist in controlling JSF costs. The U.S. DoD's history with cooperative programs, such as the

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[133] U.S. Department of Commerce, Bureau of Industry and Security, Offsets in Defense Trade, Thirteenth Study,(Washington D.C.:GPO, December 2008), ii–iii http://www.bis.doc.gov/defenseindustrialbaseprograms/osies/offsets/13th_report_to_congress.pdf.

[134] U.S. Department of Defense, *JSF International Industrial Participation,* 13.

Army's Medium Extended Air Defense System,[135] have experienced cost and schedule problems because such programs focused on meeting industrial work share requirements rather than pursuing a cost-effective acquisition strategy. Another example of coproduction programs employing traditional work share programs, the F-16 Multinational Fighter Program, often experienced cost premiums to the program in terms of increased manufacturing costs associated with use of foreign suppliers. In contrast, the JSF program's acquisition approach is expected to award contracts to the most competitive suppliers.[136]

However, to compete on the JSF's high technology aerospace subcontracts, each participant nation must be competitive enough to bid on the subcontract. The best value approach requires that competitive nations belonging to a sound defense industry have the resources to compete with others. Were participant nations unable to compete with the others, it might cause problems among the allied nations that could affect the success of the program.

Finally, the best value acquisition strategy is designed to replace traditional offset agreements which are considered economically inefficient for complex contracts such as the JSF program. Figure 10 shows JSF sourcing via the best value acquisition approach.

[135] The Medium Extended Air Defense System, MEADS, is a transatlantic cooperative effort between the United States, Germany, and Italy to develop an air and missile defense system that is tactically mobile and transportable. It will be capable of countering tactical ballistic missiles and air-breathing threats, including cruise missiles. (Taken from: http://www.globalsecurity.org/space/systems/meads.htm).

[136] U.S. General Accounting Office, Joint Cooperative Program Needs, GAO-O3-775, 15.

JSF Sourcing Based on Best Value

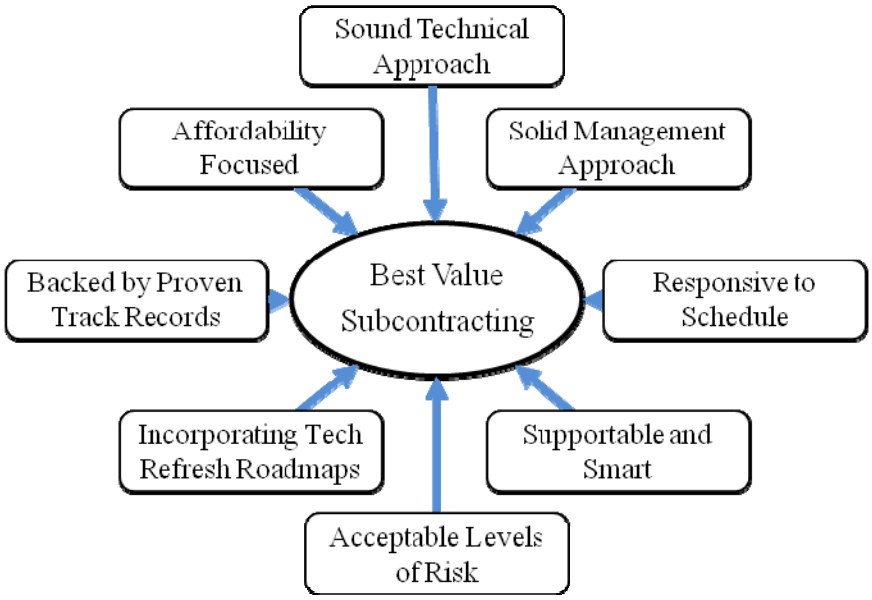

Figure 10. JSF Sourcing on Best Value. *Source:* Loys Gray, "F-35 International Support Equipment Briefing," 22, 23, 24 May 2007, www.lockheedmartin.com.

C. PARTICIPATION LEVELS

Another unprecedented feature of the JSF program is the allied nations' participation timing and levels. The nations involved in the program began participation at the inception of the program, starting with the U.K.'s commitment in 1995. Previous aircraft programs, such as the F-16 program, did not have participant nations' involvement until the later phases[137] and were driven by offset agreements. Co-productive nations did not contribute to the design or development of the program. Unlike previous international cooperative acquisitions, earlier involvement in the JSF program gives more leverage to the participant nations in contributing to the design and

[137] Schreiber, "JSF International Business Strategy", NATO's Nations and Partner for Peace, 165.

aircraft qualifications, and provides insight into the program development and associated costs. Thus, participant nations become bigger stakeholders in the program.

The JSF program has three phases: the concept demonstration phase, the system development and demonstration phase, and the production, sustainment, and follow on development phase. During the concept development phase, the U.K. was the only full cooperative partner, level I, by virtue of a 200 million dollar contribution to the program. The U.K. is entitled to full program and structural data, and has the ability to influence aircraft design and performance characteristics. Level II partners include Denmark, the Netherlands, and Norway, investing 30 million dollars each. Their contributions entitle them to limited program data and requirement design. Level III partners, Canada and Italy, each funded 10 million dollars in the JSF program. They are entitled to limited access to program information and representation, but have no influence on requirements. Level IV partners include Turkey (which paid 6.2 million dollars[138]), Singapore, and Israel; these nations are entitled to negotiate the cost, performance, and model of the aircraft. Australia did not participate in this phase. At this phase, the nations had influence on the program based on their financial contributions.

The second phase is the SDD phase, which began in 2001 and will continue through 2012. At the SDD phase, the allied nations cumulatively contributed 4.5 billion dollars, 10.9 percent of the SDD funding, for the JSF program at the three levels of partnership arrangements. The corresponding benefits include airspace technology transfer, insight into the design and development process, and membership on management decision-making bodies dependent on their financial contributions. (Figure 11 details participation levels and average investment amounts.) Industry to industry relationships begin at the SDD phase, and the participant nations' defense companies can bid on the prime contractor's subcontracts. This phase is the most important phase in establishing sound relationships among participant nations, prime contractors, and participant nation's defense industries. Undoubtedly, a cooperative relationship will

138 Global Security, F-35 Joint Strike Fighter (JSF) Lightning II, International Partners, http://www.globalsecurity.org/military/systems/aircraft/f-35-int.htm.

enhance the success of the program and will affect the program's affordability. At the SDD phase, the participant nations can withdraw from the program without financial punishment. Hence, to keep them in the program, the JSF should work to satisfy participant nations regarding program efficiency and effectiveness.

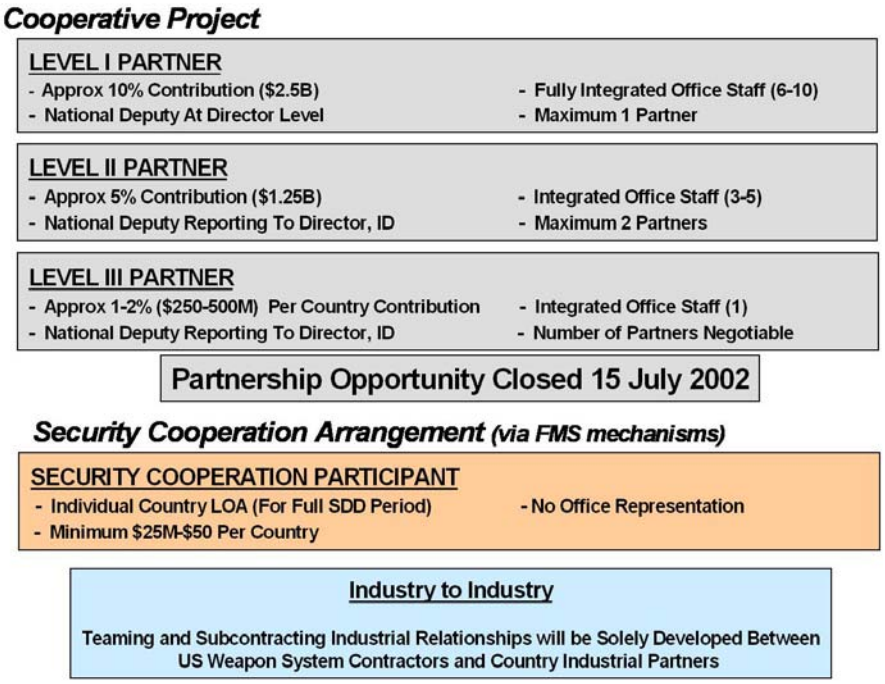

Figure 11. JSF SDD Phase International Participation. *Source:* Schreiber, JSF International Business Strategy, NATO's Nations and Partner for Peace, 166.

The last and longest phase is the PSFD phase. It will cover the entire service life of the F-35 aircraft, beginning from the first production. This phase offers no distinction in participation level; participant nations announce their commitment to acquire a certain quantity of aircraft according to a pre-established time schedule. If a participant nation decided to withdraw its commitment to purchase the aircraft after participation in this phase, the country could be penalized financially. Unlike the SDD phase, the cost is here divided on a fair share basis determined by the contribution of each nation. Also, unlike the SDD phase, the PSFD phase is an agreement among all partner nations.

The JSF program's commensurate participation approach is serves as a valuable model for prospective international cooperative acquisitions. The approach grants benefits according to investment. But commensurate participation does not prohibit competitive bids on the subcontracts; there are no proportionality restrictions on the subcontract.

D. AFFORDABILITY

Affordability is a pillar and highly advantageous characteristic of the JSF program. The Web page of the JSF program strongly emphasizes the program's vision as "delivering and sustaining the most advanced, affordable strike fighter aircraft to protect future generations worldwide."[139] To develop an advanced but affordable aircraft, several new acquisition approaches have been implemented in the JSF program, such as comprehensive international participation, the best value acquisition approach, the production of common three version aircraft, and technology transfer from allied nations.

Several program, design, and technical changes have rendered the original JSF business case beyond execution,[140] and have resulted in significant cost increases and schedule delays. Since the inception of the SDD phase in October 2001, the average program unit cost has grown by over 50 percent. In addition to the cost increase, full rate production of the first JSFs to the warfighter has been delayed by 2.5 years. Opponents liken the program to the failed F-22A program because of its substantial cost increases, schedule delays, reduced number of planned aircraft,[141] and immature technology. These problems have created concern about the health of the program among the U.S. public and partner nations.

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139 F-35 Joint Strike Fighter Program Office, F-35 Leadership, http://www.jsf.mil/leadership/.

140 U.S. Government Accounting Office. Opportunity to Reduce Risks, GAO-05-271, 1.

141 U.S. Government Accountability Office, Tactical Aircraft: Recapitalization Goals Are Not Supported by Knowledge-Based F-22A and JSF Business Cases. GAO-06-487T. (Washington, D.C.: March 16, 2006). 9, http://www.gao.gov/new.items/d06487t.pdf.

Since 2005, the GAO has leveled steady criticism at the JSF for departing from the DoD policy preference that calls for adopting an evolutionary approach to acquisitions. The GAO's findings for cost increase and schedule delays can be listed as follows:

- Lack of a knowledge-based evolutionary acquisition approach,
- Concurrence of design, development, testing and manufacturing,
- Heavy Investment in production before testing has demonstrated acceptable performance of the aircraft, and
- Procurement of a quantum leap aircraft under cost reimbursement type contracts without 100 percent flight test results.

GAO reports issued since 2005 express concerns that the program's acquisition strategy does not fully follow the intent of DoD's evolutionary, knowledge-based acquisition policy that is based on best practices.[142] A knowledge-based, evolutionary business case for the product requires that developers

- Make a clear description existing needs,
- Ensure that resources are available to develop a product that will meet the need,
- Determine that the product developer has a knowledge-based plan and strategy to deliver the product,
- Establish reasonable estimates for cost, delivery time, and quantities, and
- Secure available funding for the product.[143]

However, instead of following a knowledge-based evolutionary acquisition approach, the program began to concurrently develop the JSF technologies, integrate and demonstrate the expected product design, and manufacture aircraft. This approach carries a high level of risk.[144]

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[142] U.S. Government Accounting Office. Opportunity to Reduce Risks, GAO-05-271, 3.

[143] U.S. Government Accountability Office, Defense Acquisitions: Measuring the Value of DoD's Weapon Programs Requires Starting with Realistic Baselines, GAO-09-543 (Washington, D.C.: April 1, 2009). 9, http://www.gao.gov/new.items/d09543.pdf.

[144] U.S. Government Accounting Office, Opportunity to Reduce Risks, GAO-05-271, 3.

The current JSF's acquisition strategy requires the purchase of 383 aircraft at a cost of 54.3 billion dollars for the U.S. DoD (for details see Figure 5 in Chapter II), and 184 aircraft at a cost of approximately 26.09 billion dollars[145] for international partner nations (for details see Table 5 in Chapter II). The strategy ultimately requires a total purchase of 567 aircraft at a cost of 80.39 billion dollars before flight test programming is fully completed in 2014. To achieve the planned LRIP phase, the U.S. DoD must make significant investments in tooling, facilities, and personnel before testing is completed in 2014. This investment is made without enough test results demonstrating that

- The aircraft's flying qualities function within the parameters of the flight envelope (that is, the set limits for altitude, speed, and angles of attack),
- The aircraft design is reliable, or
- A fully integrated and capable aircraft system can perform as intended.[146]

Starting production without mature design and technology or without all flight test results significantly increases risk of costly design changes that will push the program over budget and behind schedule.[147] In other words, problems discovered late in flight testing could cause further cost increases, changes in manufacturing process, schedule delays or late delivery, and reduced quantity and reliability.[148] Figure 12, prepared by the GAO, is a notional illustration showing the impact of a highly concurrent acquisition strategy relative to a less concurrent strategy that captures key design and manufacturing data before production begins.[149]

[145] The average unit cost for 2014 is calculated at 141.78 million dollars. According to Figure 5, 383 aircraft cost 54.3 billion dollars, and thus one aircraft costs 141.78 million dollars.

[146] U.S. Government Accounting Office, Progress Made and Challenges Remain, GAO-07-360, 16.

[147] Ibid., 16–17.

[148] U.S. Government Accounting Office, Opportunity to Reduce Risks, GAO-05-271, .3.

[149] U.S. Government Accounting Office, Progress Made and Challenges Remain, GAO-07-360, 16–17.

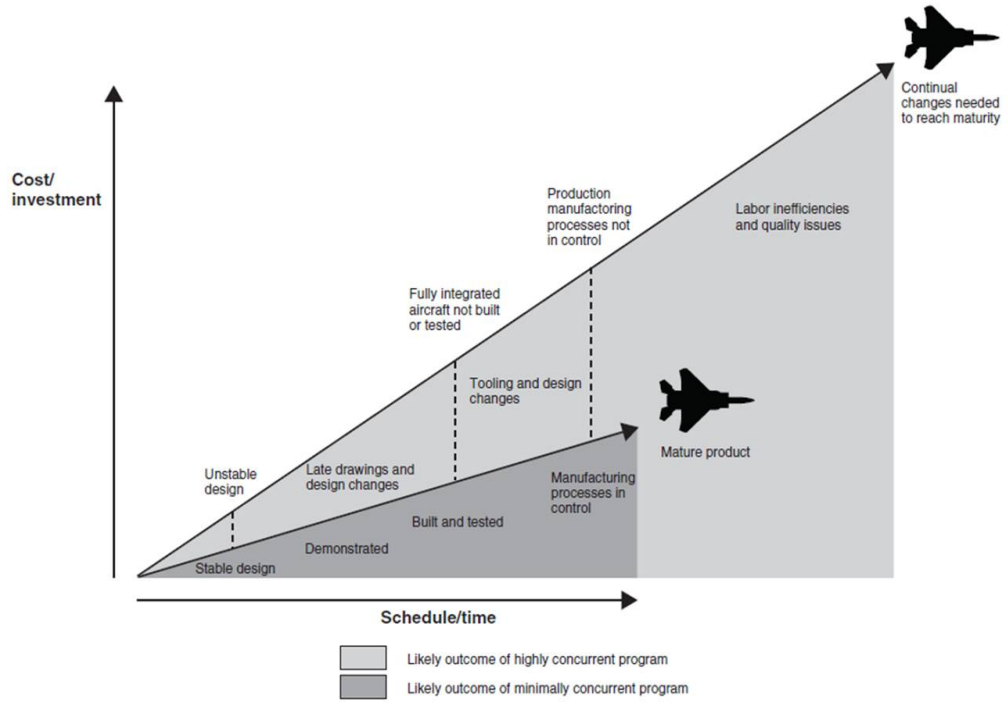

Figure 12. Notional Illustration Showing the Different Paths That JSF Development Can Take. *Source:* GAO Report, GAO-07-360, 17.

Another criticism regarding affordability is that the uncertainties in the program may negatively affect cost effectiveness. The JSF acquisition strategy assumes the use of a cost-reimbursement type contract for initial production, placing a high risk burden on the government during the early production phase.[150] According to FAR Part 16.301, cost-reimbursement types of contracts provide for payment of allowable incurred costs to the extent prescribed in the contract. Cost-reimbursement contracts are suitable for use only when uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed-price contract. As seen in Figure 13, cost-reimbursement contracts for weapon production are considered appropriate when the program lacks sufficient knowledge about system design, manufacturing processes, and testing results to establish firm prices and delivery dates. Buth with cost-reimbursement contracts, as evidenced in the JSF program, a greater cost

[150] U.S. Government Accounting Office, Opportunity to Reduce Risks, GAO-05-271, .3.

risk is placed on the buyer, in this case the U.S. DoD and partner nations. In contrast, a fixed-price contract provides for a pre-established price, places more of the risk and responsibility for costs on the contractor, and provides more incentive for efficient and economical performance.[151]

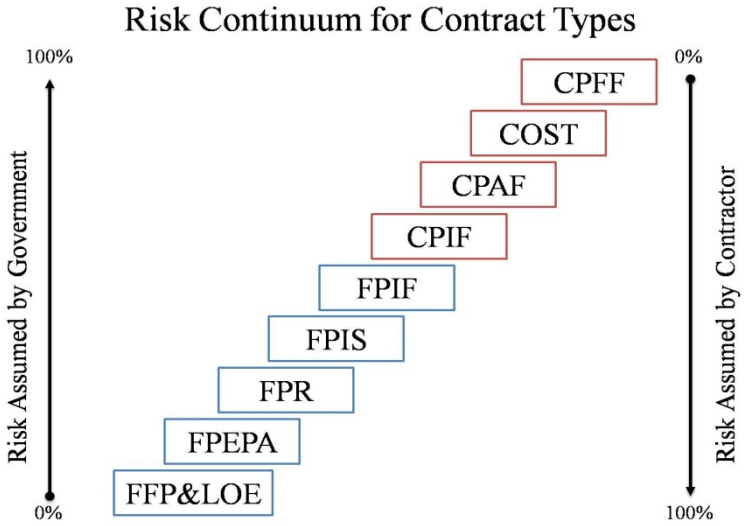

Figure 13. Risk Continuum for Contracts Types. *Source:* Elliot Cory Yoder, "Cost and Price Analysis Lecture" Cost and Price Analysis & Negotiations Course, NPS, Monterey, CA, July 2009.

Under its current strategy (see Figure 5), the U.S. DoD will switch from a cost-reimbursement contract to a fixed-price contract after 2013. In 2013, a total of 362 aircraft will have been produced for the U.S. and partner nations (see Table 5). That means 11.4 percent of entire production will be manufactured under a cost-reimbursement contract. Thus, the significant financial risk will be shared by the U.S. and partner nations' governments. Consequently, the uncertainties inherent in concurrently developing, testing, and producing the JSF aircraft prevent the pricing of initial production orders on a fixed-price basis.[152]

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[151] U.S. Government Accounting Office, *Accelerating Procurement*, GAO-09-303, 13.

[152] U.S. Government Accountability Office, Recapitalization Goals Are Not Supported by Knowledge-Based F-22A and JSF Business Case, GAO-06-487T, 13–14.

The GAO believes that cost increases and schedule delays are a result of the U.S. DoD's concurrent design, development, testing, and production processes. The GAO therefore recommends that JSF institute a knowledge-based evolutionary acquisition strategy for an affordable and on-time aircraft:

> A key to successful product development is the formulation of a business case that matches requirements with resources—proven technologies, sufficient engineering capabilities, time, and funding—when undertaking a new product development. First, the user's needs must be accurately defined, alternative approaches to satisfying these needs properly analyzed, and quantities needed for the chosen system must be well understood. The developed product must be producible at a cost that matches the users' expectations and budgetary resources. Finally, the developer must have the resources to design and deliver the product with the features that the customer wants and to deliver it when it is needed.[153]

E. CONCLUSION

The U.S. and eight international partners gathered to design, develop, and produce a fifth generation aircraft for use by various services such as the Air Force, Marine Corps, and Navy. Allied nations were also drawn to participation by the promise of opportunities to exchange technology and information among the cooperative nations, and to gain technological, economic, political, and operational benefits.

The core objectives of the JSF program touch four specific areas. These are political/military, economic, technological, and operational objectives. The political/military objective is to enhance defense relationships with key allies. However, the life cycle time for the JSF program is more than 60 years. So, to successfully reach the political objective, the participant nations must have stable relationships. Otherwise, compromised alliances might affect the program's core focuses of affordability and supportability.

The economic objective is to decrease JSF program costs by virtue of partner contributions. So far, the allied nations have contributed 4.5 billion dollars to the program. They directly and proportionally benefit from the program's technology sharing

[153] U.S. Government Accounting Office, Opportunity to Reduce Risks, GAO-05-271, 6.

and program's control. They also benefit indirectly by granting visibility to their aerospace companies, increasing the likelihood of future cooperative programs.

The technical objective is to increase access to the best technologies of foreign partners. The U.S. benefits from technology previously developed by allied nations. The allied nations gain access to the program's newly developed technology in proportion to their investment.

The operational objective is to improve mission capabilities in future coalition operations through interoperability within the allied forces. The F-35s will make allied nations' aircraft compatible with each other for future operations.

In order to develop this complicated aircraft, the U.S. DoD has implemented an unprecedented acquisition strategy and envisaged that this innovative strategy will be a model for all prospective international cooperative acquisitions. The best value strategy, international partners earlier involved to the program, and leveled program participation are significant features of the JSF program acquisition strategy.

The best value approach will replace offset agreements for complicated defense system and weapons programs such as the F-35 program. An inventive alternative to traditional work share programs, it does not guarantee any work share for partner nations. This approach requires that partner nations bid competitively to win the contracts. Partner nations should possess relatively equal technological capabilities in order to create a competitive environment.

Leveled partnership provides participant nations leveled benefits and a voice in the program commensurate with their investments. It prevents those participant nations with reduced investments from having an equal share in decisions that can affect the entire program.

In spite of all efforts and unprecedented approaches, the program's unit cost has increased 50 percent since the outset of the SDD phase, and the schedule has been delayed by 2.5 years. GAO reports express the reasons for cost increase and schedule delays in terms of the U.S. DoD's departure from a knowledge-based evolutionary

acquisition approach and a reliance on the concurrency of design, development, testing, and production phases. These two features create uncertainties which prevent the program from the switch from cost-reimbursement contracts to fixed-cost contracts.

In light of these problems, the GAO recommends that the U.S. DoD use a knowledge-based evolutionary acquisition approach before committing resources to new product development. It advises that the DoD gather evidence that (1) the Warfighter's needs are valid and can best be met with the chosen concept and quantities, and that (2) the chosen concept can be developed and produced using existing resources—that is, proven technologies, design knowledge, adequate funding, and adequate time to deliver the needed product.

IV. TURKEY AND THE JSF PROGRAM

> The significant military threat which was prominent in Cold War period has been replaced by the growing security problems such as terrorism called asymmetrical threat, religious fundamentalism, widespread use of weapons of mass destruction, illegal migration movements, sharing of scarce water resources. Due to its geopolitical position, our country is at a location where the problems mentioned above have been occurred. To overcome all these security issues having strong military forces is essential for our country.[154]
>
> General Hasan Aksay
> Turkish General Staff War Colleges Commander

A. TURKEY'S PARTICIPATION IN THE JSF PROGRAM

Since the beginning of the 1990s, Turkey has been looking for a new aircraft to replace its F-16 and F-4 aircraft, which are scheduled to leave service around 2012 to 2015. In 1999, Turkey participated in the JSF program's concept development phase by contributing 6.2 million dollars as a level IV, foreign military sale partner. In 2002, Turkey participated in the JSF SDD phase, paying 175 million dollars as a level III partner.

Before the end of 2006, Germany, Italy, Spain, and Britain, the Eurofighter group, invited Turkey several times to participate in the Eurofighter Typhoon program.[155] In 2006, before Turkey's sponsorship in the JSF PSDF phase, the Eurofighter group proposed to Turkey an "equal partnership with equal voting rights as other member nations have" and a nine billion dollars work share for its local defense industry if the Turkish government committed to buying 120 fighters. Six billion dollars of work share would be allocated for an 80 aircraft purchase and 3.2 billion dollars of work share

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[154] Hasan Aksay, Speech delivered by the Turkish General Staff War Colleges Commander at the Turkish General Staff War Colleage Graduation Ceremony, Istanbul, July 24, 2009, http://www.hurriyet.com.tr/gundem/12137450.asp.

[155] Eurofighter Typoon, "Turkey participation in Eurofighter programme," September, 30, 2005, http://www.eurofighter.com/news/article215.asp.

earmarked for a purchase of 40 aircraft. The group pledged to deliver the first batch of aircraft by 2010. The group also offered Turkey access to source codes and other critical technologies, an enhancement package, full access to repair capabilities for the aircraft, and the authority to use the aircraft anywhere, at any time in line with Turkish military doctrine.[156]

However, despite the Eurofighter group's advantageous offer, Turkey selected the U.S.-led JSF program over Europe's Eurofighter Typhoon. Turkey chose the JSF program because officials felt that the aircraft provided the most value at the lowest cost.[157] Then, at the beginning of 2007, Turkey participated in the JSF PSFD phase by committing to purchase 100 F-35A CTOV at a cost of around 10 billion dollars at the 2007-value. The Turkish Air Forces will field the first F-35 in 2012 and the last aircraft in 2021.

B. TURKEY'S EXPECTATIONS OF THE JSF PROGRAM

According to the U.S. DoD's JSF International Industry Participation analysis, there are two primary reasons why Turkey participated in the JSF program. The first motivation is the positive effect on industry in terms of increased revenues, jobs, and technological expertise. The second motivation is the upcoming need to replace existing, aging fighter aircraft.

At the signing of the Memorandum of Understanding of JSF SDD in 2002, Turkish Minister of National Defense, Mr. M.VECDÎ GÖNÜL, stated Turkey's expectations:

> This program will be a very good opportunity for us to contribute to protecting the global peace as well as improving our national security. We will also benefit from a state-of-the-art technology and the affordability-based cooperative production and sustainment. On top of that, this program will create a comprehensive tool to accelerate the existing good-faith relationship between the two strategic allies in a variety of

156 TDN Defense Desk, "Eurofighter Offers Turkey $9 Billion Local Work," The Turkish Daily News, November 30, 2006, http://gbulten.ssm.gov.tr/arsiv/2006/11/30/01.htm.

157 U.S. Department of Defense, *JSF International Industrial Participation,* .69.

> cooperative areas. For this reason, Turkey has been fully supporting and participating in all cooperative efforts within the early CDP and SDD phases of the program since 1999. We will be attaching a government-level concentration and allocating a significant amount of national resources throughout the Program.
>
> Turkey is the country with the lowest national income per capita among participant countries of JSF Program. It is also worth mentioning that, the good-faith cooperation to be pursued among the governments of the partner nations in this program will inherently be extended to our industries also, as to create a sound basis for a reliable business relationship.[158]

As stated by the Turkish Ministry of National Defense, the Turkish Government sees the JSF program as an opportunity to improve its defense industry and to benefit from a cooperative acquisition through technology transfer and a good-faith relationship. Turkey expects substantial financial, political, and technological returns in addition to obtaining an affordable advanced technology aircraft that the country could not afford to develop on its own. As mentioned in the DoD's JSF International Industrial Participation Study, Turkey's economic expectations outweigh other concerns. An e-mail to the author on June 05, 2009 from Turkish Undersecretariat for Defence Industries states that Turkey's ultimate target for industrial return is at least 50 percent of the program's total acquisition cost, with approximately 30 percent return on investment. Currently, Turkish Defense Industry contractors are competitively bidding on the program's subcontracts.

Turkey's expectations of the JSF program can be summarized as follows:

- To benefit from state-of-the-art technology,
- To obtain affordable aircraft,
- To improve a good-faith relationship between the two strategic allies,
- To bid on subcontracts on a best value basis to capture at least 50 percent of the acquisition cost, and
- To create a sound basis for a reliable business relationship.

[158]Savunma Sanayii Müsteşarlığı, Türkiye, Müşterek Taarruz Uçağı (JSF) Projesi Üretim Evresi'ne Katıldı, January 25, 2007, http://www.ssm.gov.tr/TR/etkinlikler/imzatorenleri/Pages/20070130_jsf.aspx.

C. TURKEY'S PROCUREMENT PLAN AND AFFORDABILITY

In 2007, Turkey committed to buy 100 F-35A CTOL aircraft. The F-35 procurement will begin in 2012 and continue until 2021, initially at a rate of 10 aircraft per year for the first three years, followed by 12 per year during 2015-2016, and reverting to 10 per year in 2017-2020, with the final six to be funded in 2021. Turkey's F-35 procurement plan and expected cost are shown in Table 12.

Turkey's F-35 Procurement Plan and Expected Cost

Year	F-35 Amount	PAUC in 2001 ($M)	Expected in Cost in 2001 ($M)	PAUC in 2007 ($M)	Expected Cost in 2007 ($M)	Cost Increase (Between 2001 to 2007)
2012	10	81.00	810.00	121.60	1,216.00	406.00
2013	10	81.00	810.00	121.60	1,216.00	406.00
2014	10	81.00	810.00	121.60	1,216.00	406.00
2015	12	81.00	972.00	121.60	1,459.20	487.20
2016	12	81.00	972.00	121.60	1,459.20	487.20
2017	10	81.00	810.00	121.60	1,216.00	406.00
2018	10	81.00	810.00	121.60	1,216.00	406.00
2019	10	81.00	810.00	121.60	1,216.00	406.00
2020	10	81.00	810.00	121.60	1,216.00	406.00
2021	6	81.00	486.00	121.60	729.60	243.60
Total	**100**		**8,100.00**		**12,160.00**	**4,060.00**

Table 12. Turkey's F-35 Procurement Plan and Expected Cost.

Like all participant nations, Turkey has been suffering from the JSF program's cost increase. As mentioned earlier, affordability was one of the dominant factors in Turkey's decision to participate in the program. As seen in Table 12, at the time when Turkey participated in the JSF program, the estimated cost of procurement was 196 billion dollars for 2,886 aircraft, which equates to a program acquisition unit cost

(PAUC) of 81 million dollars per aircraft. The average procurement cost (APUC) (which does not include R&D or other costs) was estimated at 69 million dollars per aircraft in 2001.

However, the U.S. DoD's SAR of September 2008 estimated the JSF program acquisition at 298.8 billion dollars for 2,456 aircraft, which equates to a PAUC of 121.6 million dollars per aircraft. The APUC is estimated at 103.9 million dollars per aircraft. The December 2007 PAUC and APUC cost estimates are, respectively, 50.1 percent and 50.5 percent higher than cost estimates made in October 2001. Thus, the program's cost for 100 F-35 at 8.1 billion dollars increased to 12.16 billion dollars in seven years, up until September 2008. Nonetheless, a GAO report issued in May 2009 points out that the JSF development acquisition cost will continue to increase, and will cost more and take longer to complete than reported in 2008 due to the contract cost overruns and extended time needed to complete flight testing.[159]

The program's cost increase forced Turkish Undersecretariat Defence Industry to seek more subcontracts. In 2002, Turkey's industrial return aim was at least 50 percent of 8.1 billion dollars, that is, slightly more than four billion dollars. But in seven years, the program cost increased 12.16 million dollars, and Turkey's industrial return expectation increased to at least 6 billion dollars. Over these years, the Turkish defense industry contractors diligently worked to win subcontracts.

D. TURKEY'S INDUSTRIAL PARTICIPATION

Before participation in the JSF program, the Turkish Government critically assessed the pros and cons of the program. Although it had a lucrative offer from the Eurofighter Group, Turkey chose the JSF program. However, the JSF's best value approach was a big concern for the Turkey Defense Industry. The JSF international cooperative acquisition approach, unlike the F-16 offset agreement, required a highly competitive approach rather than a guaranteed work share. Turkey had made a tough decision. The Eurofighter Group had guaranteed a 9 billion dollar work share in return

[159] U.S. Government Accounting Office, Strong Risk Assessment Essential, GAO-09-711T, 2.

for a commitment to purchase 120 Typhoon. By participating in the JSF program, they were volunteering to compete with aerospace giants such as BAE, Goodrich, and Smiths Aerospace from the U.K.; ASE SPA, Fiat Avio, and Galileo Aviance from Italy; Philips Aerospace and SP Space from the Netherlands; Magellen, Pratt&Whitney Canada, and Casabank Technologies from Canada; Volvo Aero from Norway; and many highly competitive aerospace companies from the U.S. and other participant nations.

The years between 2002 and 2004 were tough years for the Turkish Defense Industry because they could not compete on subcontracts. In fact, Turkish officials believed that they were not informed of the complete spectrum of available JSF contracts. After 2005, the Turkish Defense Industry contractors began to compete on the program subcontracts. According to an e-mail received by author from the Turkish Undersecretariat for Defence Industries states that nine Turkish companies, including Aselsan, TUSAS Aerospace Industries (TAI), and the privately owned KaleKalip, had acquired about 7 billion dollars worth of work on the JSF program as of June 2009. As part of this, Northrop Grumman and TAI of Turkey signed a Letter of Intent (LoI) for F-35 Lightning II Joint Strike Fighter work that could be worth up to three billion dollars over the next 20 years. The LoI, signed in February 2007, will allow TAI to become a second source production centre for a minimum of 400 centre fuselage sections.[160] In 2008, TAI opened a new advanced composites manufacturing production facility in Ankara for the JSF program. Currently, Turkish Defense Industry contractors are working on a wide range of JSF components, and they are expecting to bid on more contracts. Table 13 shows the contracts already awarded to Turkish defense contractors.

[160] The same information can be found at:, “Venturing out: Turkey Country Briefing, FEATURES”, Jane's Defence Weekly, April 21,2009. However, it states the total awarded contract amount as 5.5 billion dollars.

Contract Definition	Contractor	Turkish Subcontractor
IPT Participation - Autolog, Life Cycle	LM IS	Havelsan
MRIU Chassis, Card Stiffeners, Card Assy	Smiths	Ayesas
AME Pylons	Marvin	TAI
Collaborative Door Uplocks	Heroux-Devtek	KaleKalip
STOVL sm machined parts	LM Aero	KaleKalip
Fluid Delivery System Precision Mechined Components	Eaton	Kalekalıp
Machining CTOL/STOVL/CV Small/Medium/Large Al&Ti Parts	LM Aero	Kalekalıp
IPT Participation	BAE SYSTEMS-Operations	TAI
Machining-Wing/Fwd Small/Medium Parts	LM Aero	Kalekalıp
Landing Gear Parts Manuf. Phase 1	Goodrich LG	Alp
EHAS Transfer Tubes	Parker Controls	Alp
Canopy Hinge Sleeve Assy Production and Assembly	LM Aero	Alp
Interoperability Analysis	LM	Milsoft
Structural Parts	NG ST	Kalekalıp
Power Conditioning Electronics	NG ST	MiKES
Crash Survivable Memory Unit Assembly	L3 Comm	Ayesas
Panoramic Display	L3 Comm	Ayesas
MRIU Production Tooling and Test	Smiths	Ayesas
MRIU Production	Smiths	Ayesas
Center Fuselage LRIP composites	NGC	TAI
CAIC* Module Production	NGMS	Aselsan
EW Components & Assemblies	BAE IEWS	Mikes
Center Fuselage Assembly and Parts	NG	TAI
Rear/ Hub	P&W	Alp
Integrated Bladed Rotor Production	P&W	Alp
Rotating Engine Parts	GE	TEI
Blisk Spool Production	GE	TEI

Shrouds	P&W	Kalekalip
Seals	P&W	Kalekalip
Rotating& Complex Engine Parts	GE	TEI

Table 13. Turkish Companies' Subcontracting for the JSF program. *Source:* Turkish Undersecretariat for Defence Industries, (Savunma Sanayii Müsteşarlığı.)

As mentioned before, Turkey's projected industrial return is at least 50 percent of program acquisition cost, with 30 percent return on investment. To date, Turkish defense companies have been awarded seven billion dollars worth of JSF contract work, that is, 57.6 percent of the total acquisition cost. The expected return on the investment amount, 30 percent of seven billion dollars, is 2.1 billion dollars. Turkish companies have already reached their goal and are looking for additional financial and technological benefits from the JSF Program. The Turkish Undersecretariat for Defence Industries is satisfied with the amount of the subcontracts and looking to realize more benefits.

The Turkish government perceives the JSF program as a premier aerospace league in which the best aviation contractors gather to develop and produce JSF aircraft. It is important to gain industrial and technological benefits beside economic and political/military benefits. The Turkish Defense Industry wants to garner prestige by winning subcontracts to produce advance technology aircraft. Competing with advanced aerospace companies will strengthen domestic industry and prepare Turkish companies for prospective competitive contracts. By establishing good relationships and demonstrating defense industry capabilities, Turkey believes that it will increase opportunities to capture more contracts for future projects. Also, thanks to the JSF contract, Turkey is developing its Defense Industry's infrastructure and creating new job opportunities via JSF contracts. For example, in 2008, TAI opened a facility to produce advance composites for F-35 fuselages in Ankara. This new facility will result in new contracts and more jobs. Thus, as mentioned by the Turkish Minister of National Defense, Turkey sees the JSF contract as an opportunity to capture industrial, economic, and technological benefits.

E. CONCLUSION

Turkey participated in the JSF program to procure affordable F-35s with substantial economic, technological, and industrial returns. Currently, it has reached 57.6 percent of its industrial return. Turkey wants to benefit from technology transfers and establish good relationships for prospective cooperative contracts.

However, beyond the benefits that have been thus far realized, the Turkish government should analyze the JSF's international cooperative acquisition strategy. Turkey has numerous cooperative agreements with several countries to design or produce a wide range of defense weapons or systems. The best value acquisition and leveled program participation approaches are good initiatives for future Turkey-led international cooperative acquisitions.

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V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

In addition to being the largest and most expensive international armaments cooperation, the JSF program is also the most complex and ambitious aircraft acquisition program among the United States, the United Kingdom, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway. The program's purpose is to develop and field a supersonic, highly common family of stealthy, next-generation strike fighter aircraft for the U.S. Navy, Air Force, Marine Corps, and eight international partners.

Over the past few decades, the increasing need for new weapons systems, requirements of interoperability among the allied nations, and the necessity to share technology and information in order to develop advanced aircraft all led the U.S. and its allies to pursue collaborative international arrangements. The JSF program officially began in 1994, and allied nations began participation in the program between 1994 and 2002. While the program is led by the U.S., all participant nations cooperate to design, develop, and produce an affordable yet advanced technology aircraft by exchanging technology and information and investing in the program with commensurate benefits. As a result, the allied nations will gain an advanced aircraft that they could not afford to develop and produce on their own, a return on their investment through work on competitively awarded subcontracts, and benefits from shared aerospace technology and data.

The complexity of such an operation required an unprecedented international cooperative acquisition strategy. Furthermore, the U.S. DoD and the JSF Program Office envisioned the program to "be the model acquisition program for joint services and international cooperation to deliver to aircraft an affordable and effective next generation strike fighter weapon system and sustain it worldwide." However, the program's cost increases, schedule delays, and significant design modifications have created debates about the health of the program over the years. Officials are questioning whether the program's untried acquisition strategy can serve as a model for prospective acquisitions.

From the outset of the program, JSF was considered to be an international cooperative acquisition program with four core objectives: political/military, economic, technological, and operational.

The political/military objective of the program is to enhance defense and political relationships among participant allied nations. However, the life cycle time of the JSF program is more than 60 years. History shows that the nation's common interests can change in less than a decade, so a 60-year partnership is politically too optimistic. To reach the political objective, the participant nations must have a goodwill and stable political relationship. Otherwise, negative relationships may affect the program's core focuses of affordability and supportability. Despite this drawback, the program is considered to have improved nations' political and defense relationships and likely will be a pioneer for future defense cooperative acquisitions. While the cooperative agreements among the participant nations have increased global defense partnerships, they will also decreases nations' independence. With one hundred defense companies from nine participant nations producing parts for the program, the political objectives of JSF make the participant nations dependent upon each other for a substantial amount of time.

The economic objective of the program is to reduce the JSF program's research and development costs through contributions from partners, and to reap the benefits of economies of scales. The allied nations have in total contributed 4.5 billion dollars to the program for the SSD phase. Thus, the U.S. reduces R&D costs by spreading costs among participant nations. The allied nations' earlier commitment to purchase untested and unproduced aircraft creates a valuable market for the U.S. defense industry. The U.S. defense industry further benefits from the economies of scales by producing 730 aircraft for allied nations in addition to 2443 aircraft for U.S. services. On the other hand, allied nations benefit from the program's technology sharing and program's control in proportion to their contribution. The partner nations' defense industrial companies bid on the subcontracts to provide a best value acquisition base. They have the opportunity to capture five dollars to 40 dollars of revenue in return for every one dollar invested in the

program. Moreover, by participating in the JSF program, partner nations become familiar with the U.S. aerospace defense industry processes, increase their technical competencies, and increase their likelihood of being awarded additional work in the future. For these reasons, the economic objective of the program outweighs the other program objectives, and on this basis, the JSF program is viewed as an economic cooperation rather than a political coalition among the U.S. and eight allied nations.

The technical objective of the program is to increase access to the cutting edge technologies of foreign partners and to share the program's technology with participant nations, depending on their investment. The U.S. benefits from advanced technology which the allied nations have already developed. For example, the U.S. benefited from allies' technology by acquiring short takeoff and vertical landing technology and the lift fan system that powers the F-35B STOVL. The allied nations benefit from the JSF program's newly developed technology in accordance with their investment. However, the participant nations are not satisfied with the shared data and technology. Some nations complain that the U.S. is reluctant to share software codes and key technologies. Technology sharing is the most frustrating and long-standing problem with the JSF program. The complexity of the cutting edge technology makes the technology transfer issues even more difficult. To date, it is evident that the U.S. DoD has developed an effective strategy to share technology with the participant nations. Nevertheless, it is difficult to satisfy all nations that have contributed varying program funding amounts and are expecting significant technology transfers. Hence, the JSF program demonstrates that technology sharing remains a problem area for prospective international cooperative acquisitions. To address this problematic issue, programs should include at their inception a clear understanding and agreement as to the kinds of technology to be shared at each level of participation. Then nations will invest on a commensurate returns basis and avoid technology share problems.

The operational objective of the program is to improve mission capabilities in future coalition operations through interoperability with the allied forces. Interoperability is the policy of the U.S. to standardize equipment (including weapons systems,)

ammunition, and fuel procured for the use of the armed forces of the U.S. stationed in Europe under the North Atlantic Treaty Organization (NATO), or at least to ensure that the equipment is interoperable with equipment of other members of NATO. The F-35s will make allied nations' aircraft compatible with each other for future operations. Interoperability is an objective of the U.S. and the U.K., but will also provide great benefits in future cooperative operations involving other nations.

In order to realize this complicated aircraft design, development, and production program, the U.S. DoD implemented an unprecedented acquisition strategy and envisioned that this innovative strategy would be a model for the future international cooperative acquisition programs. The best value strategy, international partners' earlier involvement to the program, and leveled program participation are significant features of the JSF program's acquisition strategy.

The best value approach replaces offset agreements for complicated defense systems and weapons such as the F-35 program. The U.S. government believes that offset agreements are appropriate for short, non-complex productions with a limited production quantity. However, the U.S. government believes that offset agreements are not suitable for complex acquisitions such as the JSF program, which requires a high proportion of subcontracting and broad allied nations' participation. To avoid the drawbacks of offset agreements, the U.S. DoD brought forward the best value acquisition approach for the JSF program. Unlike previous traditional work share programs, it does not guarantee any work share for partner nations. This approach requires that partner nations bid competitively to win the contracts. To foster successful competitive bidding on contracts, partner nations should possess relatively equal technological capabilities. If there are no technological discrepancies among participant nations and they are thus highly competitive, a subcontract can be awarded on a best value basis and the acquisition strategy becomes a good model for future acquisitions.

Another unprecedented feature of the JSF program is the allied nations' participation timing and participation levels. Unlike previous cooperative armaments programs, the partner nations were granted an opportunity for involvement during the

concept phase of the program. Earlier involvement in the program gives more leverage to the participant nations in contributing to the design and aircraft qualifications, and provides insight into the program development and associated costs. Thus, participant nations become greater stakeholders in the program. The JSF program's commensurate participation approach serves as a valuable model for prospective international cooperative acquisitions. This approach grants nations benefit in proportion the their contributions. Furthermore, the approach provides participants nations leveled benefits and a voice in the program commensurate with their investments It prevents those participant nations with reduced investments from having an equal share in decisions that can affect the entire program. Moreover, commensurate participation does not prohibit competitive bids on the subcontracts; there are no proportionality restrictions on the subcontracts.

In spite of JSF's innovative approaches, the program's unit cost has increased by 50 percent since the outset of the SDD phase, and the schedule has been delayed by 2.5 years. GAO reports have expressed the reasons for cost increase and schedule delays in terms of the U.S. DoD's departure from a knowledge-based evolutionary acquisition approach and a reliance on the concurrency of design, development, testing, and production phases. These two features create uncertainties that prevent the program from migrating from cost-reimbursement contracts to fixed-price contracts. So, instead of prime contractors, the U.S. government partner nations assume the program risk for 362 aircraft, 11.4 percent of the entire production.

GAO reports recommend that the U.S. DoD use a knowledge-based evolutionary acquisition approach before committing resources to new product development. The GAO advises that the DoD gather evidence that (1) the Warfighter's needs are valid and can best be met with the chosen concept and quantities, and that (2) the chosen concept can be developed and produced using existing resources—that is, proven technologies, design knowledge, adequate funding, and adequate time to deliver the needed product.

JSF's contribution to future acquisitions will become clearer with time. The JSF program's acquisition strategy may indeed serve as a model if the program meets the conditions proposed by this MBA project:

- The participant nations should have a goodwill and stable relationship over the long term in order to sustain affordability and sustainment of the aircraft.
- For long term political partnerships, the partner nations' governments, defense industries, congresses, and public should be determined and eager for cooperation.
- Technology share levels should be determined at the inception of the program to prevent potential technology sharing problems such as those of the JSF program.
- All participant nations should possess relatively equal technological capabilities, and all participant nations should be highly capable of competitive bidding on subcontracts.
- The JSF program's commensurate participation approach should be implemented for future cooperative agreements. The approach provides participant nations leveled benefits and a voice in the program commensurate with their investments. It prevents those participant nations with reduced investments from having an equal share in decisions that can affect the entire program.
- In order to provide more realistic cost estimates, JSF leaders should implement a knowledge-based evolutionary acquisition approach before committing resources to new product development.
- JSF leaders should avoid concurrent design, development, testing, and production processes requiring significant investment without adequate testing results.

Chapter IV analyzes Turkey's participation in the JSF program. As mentioned in that chapter, despite the Eurofighter group's advantageous offer, Turkey participated in the JSF program to procure affordable F-35s with substantial economic, technological, and industrial returns. Turkey selected the U.S.-led JSF program over Europe's Eurofighter Typhoon because it felt that JSF provided the best value at the lowest cost.

Turkey's expected industrial return is at least 50 percent of the program acquisition cost, with a 30 percent return on their investment. To date, Turkish defense companies have been awarded seven billion dollars in contracts, that is, 57.6 percent of the total acquisition cost. The expected return on the investment amount, 30 percent of seven billion dollars, is 2.1 billion dollars. Turkish companies have reached their goal and are looking for more financial and technological benefits from the JSF Program. But the program's constant cost increases have forced Turkish companies to competitively bid on subcontracts in order to reduce the cost of aircraft by increasing their rate of return.

Industrial participation is extremely important for the Turkish defense industry. The Turkish government perceives the JSF program as an premier aerospace league in which the best aerospace contractors gather to develop and produce the JSF aircraft. The Turkish Defense Industry wants to garner prestige by winning the subcontracts to produce advanced technology aircraft. Competing with advanced aerospace companies will strengthen its domestic industry and prepare it for participation in other competitive contracts. By working with nine countries on the JSF program, the Turkish government gains familiarity with allied nations' aerospace industry manufacturing processes, increases its technical competencies, and increases its likelihood of being awarded additional work in the future. Moreover, the JSF contract has allowed Turkey to develop its Defense Industry's infrastructure and to create new job opportunities for the Turkish people via JSF contracts. For example, in 2008, TAI opened a facility in Ankara to produce advance composites for F-35 fuselages. A new facility will generate new jobs and new contracts. Thus, as mentioned by Turkish Minister of National Defense, Turkey sees the JSF contract as an opportunity to capture industrial, economic, and technological benefits.

However, regardless of the benefits reaped thus far, the Turkish government should analyze the JSF's international cooperative acquisition strategy. Turkey has numerous cooperative agreements with several countries to design or produce a wide range of defense weapons or systems. The best value acquisition and leveled program participation approaches are good initiatives for future Turkey-led international cooperative acquisitions.

B. RECOMMENDATIONS

This MBA project analyzes only one aspect of the JSF program, international cooperative acquisition. Rather than providing a case-by-case examination of participant nations, the project looks broadly at the overall program, dedicating one chapter to the author's home country, Turkey. Further research may add greater understanding of the JSF program and its contributions to prospective acquisition projects. First, research might analyze the industrial participation of international companies. Questions regarding the percentage of JSF work being subcontracted to international companies are considered proprietary and were answered by Lockheed Martin and Northrop Grumman. If the JSF program later discloses international partners' industrial participation data, such as subcontracting percentages and dollar values, research might address the efficiency of the best value acquisition strategy.

Second, additional research might analyze the benefits and liabilities of each nation resulting from the JSF program's international cooperative acquisition strategy, with a particular focus on the benefits and liabilities of the U.S.

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